PI-SCX System

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Princeton Instruments

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Chapter 1
Introduction

When Flexibility Counts

Princeton Instruments knows that a camera designed to detect x-ray photons for scientific research needs to be flexible. X-ray scattering from complex crystals such as proteins requires high dynamic range and low-noise readout, whereas scattering from materials like polymers, fibers, and powders requires deep cooling and rapid imaging to capture phase or morphological changes during thermal or mechanical processing. Shutterless operation, low noise, and the ability to select a fiber ratio up to 5:1 make the Princeton Instruments PI·SCX system an ideal choice for both of these applications.

In fact, PI-SCX high-performance systems are designed specifically for applications like x-ray tomography, x-ray topography, medical x-ray imaging, nondestructive testing (NDT), streak tube readout, and image intensifier readout.

When a 1:1 fiberoptic-coupling configuration is chosen, these cameras are well suited for streak tube and image intensifier readout or low x-ray flux imaging. A software-programmable high-sensitivity or high-capacity amplifier means that the PI-SCX system can also provide x-ray photon-counting capability with 16-bit dynamic range.

Fiberoptic Expertise

The PI-SCX camera system utilizes Princeton Instruments' patented fiberoptic-coupling technology (US Patent 5,134,680) to ensure the highest possible resolution. This process eliminates any intermediate fiberoptic faceplate or unreliable oil layer between surfaces. An optional phosphor screen (GdOS:Tb) that absorbs x-rays and emits visible light (~550 nm) can also be coupled to the CCD with a fiberoptic in order to detect x-rays. When the highest sensitivity is required, such as when detecting low flux or lower x-ray energies (~5 keV), smaller taper ratios and back-illuminated CCDs are offered. For distortion-free imaging, a 1:1 fiberoptic system is recommended, while for maximum field of view – ideal for high-brilliance sources like third-generation synchrotrons – tapers with diameters as large as 165 mm are recommended.

Shuttering and Synchronization

Electrical timing signals are available from the camera controller for synchronization with a customer-provided x-ray shutter. The CCD can be continuously cleared of dark charge while waiting for an exposure to begin. Exposures that are much longer than the CCD readout time can be performed without a shutter, as the amount of smearing (due to continued exposure during readout) will be low.

Low-Noise Configurations

The PI-SCX system provides either a forced-air or water-cooling option to reduce dark current. The thermoelectric (Peltier) design and precision electronics provide very high precision as well as the capability to set the required temperature.

For higher performance, models with the phosphor, fiberoptic, and CCD all entirely contained within a vacuum are also available. This configuration allows deeper cooling while eliminating condensation on the phosphor surface. Another configuration, one in which the fiberoptic extends outside the vacuum, allows the flexibility of changing scintillators/phosphors for specific x-ray energy without breaking vacuum or coupling the camera system to streak tubes or image intensifiers.

Software Solutions

The PI-SCX camera runs under WinView and WinSpec, Princeton Instruments' 32-bit Windows® software packages designed for imaging and spectroscopy, respectively. They provide comprehensive image or spectra capture and display functions, so you can perform data acquisition without having to rely on third-party software. The packages also facilitate snap-ins to permit easy user customization of any function or sequence. Windows DLLs are available, which allows you to write your own software. This makes integrating the system into larger experiments or instruments a straightforward endeavor.

Custom Design

On a special-order basis, custom fiberoptic-taper configurations can be provided, including designs that support electron backscatter imaging, simultaneous wide- and small-angle x-ray scattering imaging, or nondestructive testing. Configurations with multiple CCD / taper assemblies can also be provided.

Contact Princeton Instruments for the latest information concerning these and other options for fiberoptically-coupled camera needs.

PI-SCX System Components

The Princeton Instruments PI-SCX system normally contains the major components shown in Figure 1 and described below. Actual system components will depend on the system configuration ordered.

- **Fiberoptic Taper CCD Camera:** X-rays pass through the Beryllium window and are absorbed by a phosphor screen that emits visible light. This light is coupled to the CCD by a reducing fused fiber optic taper. The CCD detects one or more visible photons per X-ray photon absorbed. Detected photons are converted to electrical signals. These are then transferred from the camera to the ST-133 Controller.

WARNING!

Do not touch the Beryllium window at the front of the camera.

Avoid abrasion of the Beryllium window since powdered Beryllium is highly toxic if ingested. Beryllium should never be handled in a way that places personnel at risk.

Units are shipped with a protective label over the Beryllium window. This label should be removed and discarded. Damage to the Beryllium window may result in loss of vacuum and improper camera operation.

- **ST-133 Controller:** Controls the camera and experiment, including the temperature set point. Collects the data and transfers it to the computer for further processing.
- **Camera-Controller Cable:** This 10' cable (6050-0484) connects from the **DETECTOR** connector (25 pins) on the back of the **ST-133** to the connector (25 pins) on the back of the camera. Note that the end that connects to the camera has a right-angle connector and is secured by a slide lock.
- **User Manuals:** PI-SCX System and WinView/32 Imaging Software. The PI-SCX manual contains the basic setup and operation information for PI-SCX camera systems. For information about WinView/32, refer to its manual and to the on-line help supplied with the program.

  Note: The system and software manuals may be provided on the software CD supplied with your system.
- **WinView/32 CD-ROM:** This CD contains the WinView/32 imaging software and related manuals in PDF format.
- **Interface Card:** Princeton Instruments (RSPI) High-Speed Serial PCI Card or USB 2.0 Card to be installed in the computer. If the computer is purchased from Princeton Instruments, the interface card will be installed at the factory.
- **Interface Cable:**
  - TAXI cable: DB9 to DB9 cable (6050-0148-CE is standard) or
  - USB cable: Five (5) meter cable (6050-0494) is standard

Figure 1. Standard System Components

About this Manual

Manual Organization

This manual provides the user with all the information needed to install a PI-SCX camera and place it in operation. Topics covered include a detailed description of the camera, installation, cleaning, specifications and more.

Notes:

1. The general identifier "ST-133" is used for both the ST-133A Controller and the ST-133B Controller. Where there is a difference, the specific identifier is used.
2. "WinX" is a generic term for WinView, WinSpec, and WinXTest application software.

Chapter 1, Introduction briefly describes the PI-SCX family of cameras; details the structure of this manual; and documents environmental, storage, and cleaning requirements.

Chapter 2, Component Descriptions provides descriptions of each system component.

Chapter 3, Installation Overview cross-references system setup actions with the relevant manuals and/or manual pages. It also contains system layout diagrams.

Chapter 4, System Setup provides detailed directions for interconnecting the system components.

Chapter 5, Operation includes a simple procedure for verifying system operation and discusses operational considerations associated with exposure, readout, and digitization.

Chapter 6, Advanced Topics discusses standard timing modes (Free Run, External Sync, and Continuous Cleans), Fast and Safe, and TTL control.

Chapter 7, Troubleshooting provides courses of action to take if you should have problems with your system.

Appendix A, Specifications includes PI-SCX camera and ST-133 specifications.

Appendix B, Outline Drawings includes outline drawings of the PI-SCX cameras and the ST-133A and ST-133B Controllers.

Appendix C, Repumping the Vacuum explains how to restore the camera's vacuum if that vacuum has deteriorated over time.

Appendix D, USB 2.0 Limitations covers the currently known limitations associated with operating under the USB 2.0 interface.

Declaration of Conformity contains the Declaration of Conformity for PI-SCX systems.

Warranty & Service provides warranty and customer support contact information.

Safety Related Symbols Used in this Manual

Caution! The use of this symbol on equipment indicates that one or more nearby items should not be operated without first consulting the manual. The same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

Warning! Risk of electric shock! The use of this symbol on equipment indicates that one or more nearby items pose an electric shock hazard and should be regarded as potentially dangerous. This same symbol appears in the manual adjacent to the text that discusses the hardware item(s) in question.

Environmental Conditions

- Storage temperature < 50°C
- Operating environment 0°C < T< 30°C
- Operating temperature range over which specifications can be met is 18° C to 23° C
- Relative humidity ≤50%, noncondensing.

Repairs

Repairs must be done by Princeton Instruments. If your system hardware needs repair, contact Princeton Instruments Customer Service. Please save the original packing material so you can safely ship the system to another location or return it for repairs.

Warnings

To prevent injury, please observe the following warnings:

Beryllium

- Do not touch the Beryllium window at the front of the camera.
- Avoid abrasion of the Beryllium window since powdered Beryllium is highly toxic if ingested. Beryllium should never be handled in a way that places personnel at risk.
- Units are shipped with protective label over the Beryllium window. This label should be removed and discarded. Damage to the Beryllium window may result in loss of vacuum and improper camera operation.
- For additional information on safe handling practices or technical data on Beryllium, contact Brush Wellman Inc. at www.brushwellman.com

Coolant

- COOLANT IS HARMFUL IF SWALLOWED. Store coolant securely and keep it out of the reach of children.

Precautions

To prevent permanently damaging the system, please observe the following precautions:

- Always switch off and unplug the ST-133 Controller before changing your system configuration in any way.
- The CCD array is very sensitive to static electricity. Touching the CCD can destroy it. Operations requiring contact with the device can only be performed at the factory.
- Never operate the camera cooled without proper evacuation or backfill. This could damage the CCD!
- Never connect or disconnect any cable while the PI-SCX system is powered on. Reconnecting a charged cable may damage the CCD.
- Never prevent the free flow of air through the equipment by blocking the air vents.
- Never operate a water-assisted or water-cooled-only PI-SCX:1300 camera with coolant at a temperature below that specified for it.

Cleaning

WARNING! Turn off all power to the equipment and secure all covers before cleaning the units. Otherwise, damage to the equipment or personal injury could occur.

Camera and Controller

Although there is no periodic maintenance that *must* be performed on the camera or the ST-133 Controller, you may clean these components from time to time by wiping them down with a clean damp cloth. This operation should only be done on the external surfaces and with all covers secured. In dampening the cloth, use clean water only. No soap, solvents or abrasives should be used. Not only are they not required, but they could damage the finish of the surfaces on which they are used.

Beryllium Window

Cleaning may be necessary to remove oil or other contaminants from the surface of the window. Because a fingerprint left on the surface will disrupt the effectiveness of the final etch or coating and because of the potential toxicity, protective gloves should be worn when cleaning the window. To clean the window, wipe it down with isopropanol and a lintless cloth. DO NOT use water. Beryllium is highly susceptible to localized pitting when in contact with the chloride and sulfate ions contained in ordinary water.

Princeton Instruments Customer Service

Refer to the contact information located on page 108 of this manual.

Chapter 2
System Component Descriptions

PI-SCX Camera

CCD Array: PI-SCX currently offers three CCD formats: the 1340x1300 array with 20x20 µm pixels, the 2084x2084 array with 24x24 µm pixels, and the 4096x4096 array with 15x15 µm pixels. All are scientific grade full-frame arrays with MPP. The application of indium tin oxide (ITO) technology to the PI-SCX:4300 array provides a QE of approximately 65% to 550 nm. When used with an x-ray scintillator screen and a software-programmable, high-capacity or high-sensitivity amplifier, these systems can effectively provide x-ray photon-counting capability with up to 16-bit dynamic range.

CCD Chamber: The vacuum-sealed CCD chamber protects the CCD from contamination as well as insulates it from the warmer air in the camera body. The inherent low humidity prevents condensation on the cooled surface of the array. The thermal barrier provided by the fiberoptic prevents the condensation from forming on the front of the fiberoptic .

PI-SCX cameras are normally shipped with a vacuum level of ~10 mTorr or better. Because this vacuum may deteriorate over time due to outgassing of electrical components, some PI-SCX cameras are designed with a built-in vacuum port that can be used to restore the vacuum to its original level. Instructions for repumping the vacuum are provided in Appendix C.

Fiber Optic: The PI-SCX fiberoptic tapers are bonded to the face of the CCD arrays with Princeton Instruments' patented fiberoptic-coupling technology. The direct bonding to the face of the array eliminates the need for an intermediate fiberoptic faceplate or an oil layer between surfaces, thereby increasing sensitivity. The PI-SCX:1300 is bonded to a 1:1 or 1.5:1 fiberoptic taper which extends outside the vacuum for a resolution of 25 lp/mm for the 1:1 taper or 16 lp/mm for the 1.5:1 taper. The PI-SCX:4096 is available with either a 1:1 fiberoptic taper (31 lp/mm, 61x61 mm field of view) or a 1.9:1 fiberoptic taper (120x120 mm field of view). The PI-SCX:4300 is available with either a 1:1 fiberoptic taper (20 lp/mm) or a 2.4:1 taper (120x120 mm field of view).

Thermoelectric Cooler: While the CCD accumulates charge, thermal activity releases electrons, generating dark current. Cooling the CCD enhances the low-light sensitivity by reducing thermally generated charge. With forced-air assistance, the PI-SCX:1300 camera's thermoelectric cooler is capable of cooling the CCD to -30°C with ±0.05°C stability at temperature lock. With 25°C water for water-assisted cooling, the PI-SCX:1300 camera can reach -35°C. With +5°C water, the PI-SCX:4096 (≤1.5:1 fiber ratio) and the PI-SCX:4300 are designed to reach -50°C. With +0°C water, the PI-SCX:4096 (>1.5:1 fiber ratio) is designed to reach -45°C

Cooling is accomplished by mounting the CCD on a cold finger, which in turn is seated on a thermoelectric (Peltier-effect) cooler. With air-cooling, the heat is transferred through the Peltier stages to internal fins and is removed by forced air. With water-cooling, a 50:50 ethylene glycol-water coolant is circulated through a heatsink thermally

connected to the Peltier. CCD temperature is controlled and monitored by the host computer and the ST-133 Controller.

Electronics: The camera electronics enclosure contains the preamplifier and array driver board. This design keeps all signal leads to the preamplifier as short as possible and also provides complete RF shielding.

Speed of data acquisition and dynamic range is determined primarily by the A/D converter used (binning on the array is also a factor). The PI-SCX is available with a 1 MHz, 16-bit readout. The PI-SCX:1300 is available with dual-speed digitization (100 kHz and 1 MHz). These 16-bit digitizers give you the choice of the 100 kHz for the better signal-to-noise ratio or the 1 MHz for increased data acquisition speed. Both the PI-SCX:1300 and the PI-SCX:4300 have dual-amplifier circuits (low-noise or high-capacity). The PI-SCX:4096 has a single readout-amplifier.

Connectors: Power, control signals, and data are transmitted between the ST-133 and the PI-SCX camera via the 25-pin D connector located on the rear of the camera.

Mounting Holes: The PI-SCX:1300 camera can be ordered with an optional tripod mount kit with three different mounting holes (1/4"-20, 3/8"-16, and M6). The PI-SCX:4096 and the PI-SCX:4300 cameras have three threaded holes on the underside of the camera body (two are M8 x 1.25 tap, 25 mm deep; and one is 1/4"-20 tap, .50" deep).

Fan: PI-SCX:1300 only. There may be a fan located inside the camera's back panel. Its purpose is:

- to remove heat from the Peltier device that cools the CCD array
- to cool the electronics.

  An internal Peltier device directly cools the cold finger on which the CCD is mounted. The heat produced by the Peltier device is then removed by the air drawn into the camera by the internal fan and exhausted through the back panel. The fan is always in operation and air cooling of both the Peltier and the internal electronics takes place continuously. The fan is designed for low-vibration and does not adversely affect the image. For the fan to function properly, free circulation must be maintained between the rear of the camera and the laboratory atmosphere.

Coolant Ports: Depending on the camera, there may be two coolant ports for water-cooling. The Inlet and Outlet ports for the PI-SCX:4096 and the PI-SCX:4300 are interchangeable, are barbed (straight or right-angled), and will accommodate 3/8" ID Tygon tubing . Optimal cooling for the PI-SCX:1300 requires that the correct ports be used for the Inlet and the Outlet. These quick-disconnect ports require 1/4" thin-wall plastic tubing.

ST-133 Controller

Electronics: The Model ST-133 is a compact, high performance CCD Camera Controller for operation with Princeton Instruments cameras. Designed for high speed and high performance image acquisition, the ST-133 offers data transfer at speeds up to 5 megapixel per second, standard video output for focusing and alignment. A variety of A/D converters are available to meet different speed and resolution requirements.

In addition to containing the power supply, the controller contains the analog and digital electronics, scan control and exposure timing hardware, and controller I/O connectors, all mounted on user-accessible plug-in modules. This highly modularized design gives flexibility and allows for convenient servicing.

POWER Switch and Indicator: The power switch location and characteristics depend on the version of ST-133 Controller that was shipped with your system. In some versions, the power switch (when located on the front panel as shown in Figure 3), has an integral indicator LED that lights whenever the ST-133 is powered. In other versions, the power switch is located on the back of the ST-133 and does not include an indicator LED.

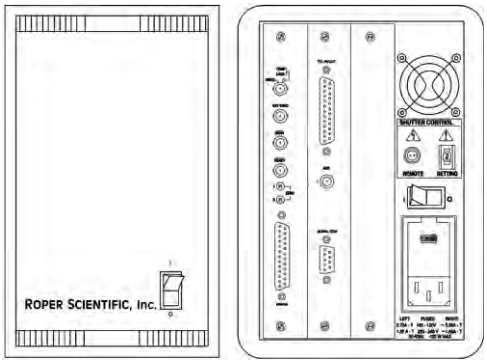


Figure 2. Power Switch Location (ST-133A and ST-133B)

Rear Panel Connectors: There are three controller board slots. Two are occupied by the plug-in cards that provide various controller functions. The third, covered with a blank panel, is reserved for future development. The left-most plug-in card is the Analog/Control module. Adjacent to it is the Interface Control module. Both modules align with top and bottom tracks and mate with a passive backplane via a 64-pin DIN connector. For proper operation, the location of the modules should not be changed. Each board is secured by two screws that also ground each module's front panel. Removing and inserting boards is described in Chapter 7, pages 80-81.

WARNING! To minimize the risk of equipment damage, a module should ***never*** be removed or installed when the system is powered.

The **Analog/Control Module**, which should always be located in the left-most slot, provides the following functions.

- Pixel A/D conversion
- CCD scan control
- Exposure control
- Timing and synchronization of readouts
- Temperature control
- Video output control

The **Interface Control Module**, which should always be located in the center slot, provides the following functions.

- TTL in/out Programmable Interface
- Communications Control (TAXI or USB 2.0 protocol)

WARNING! Always turn the power off at the Controller before connecting or disconnecting any cable that interconnects the camera and controller or serious damage to the CCD may result. This damage is ***NOT*** covered by the manufacturer's warranty.

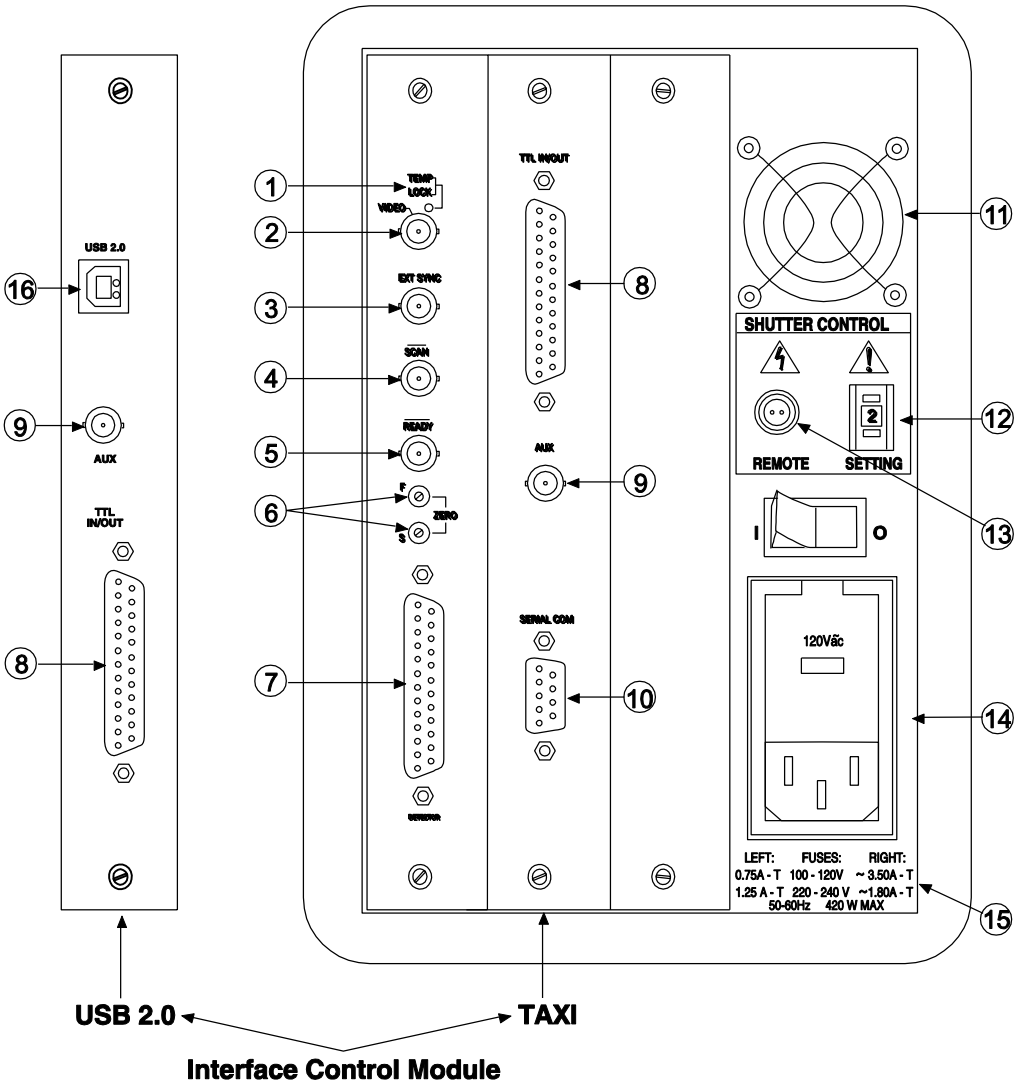
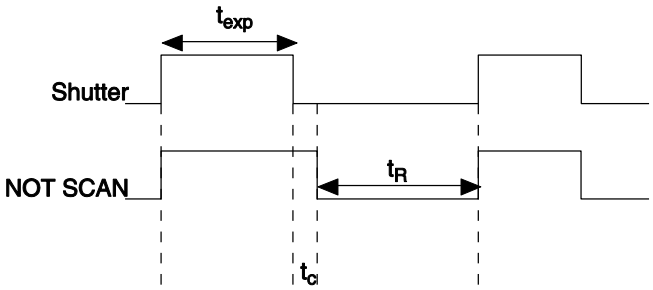


Figure 3. ST-133 Rear Panel

Rear Panel Features: The descriptions of the rear panel connectors are keyed to Figure 3. Depending on your system, either the TAXI or the USB 2.0 Interface Control Module will be installed in the second from the left slot (as you face the rear of the ST-133). The TAXI module is shown in that position.

#	Feature
1.	**Temperature Lock LED:** Indicates that the temperature control loop has locked and that the temperature of the CCD array will be stable to within ± 0.05°C.
2.	**Video Output:** If labeled Video, composite video output is provided at this connector. The amplitude is 1 V pk-pk and the source impedance is 75 Ω. Note that video output is not currently supported under USB 2.0. If labeled Aux, this output is reserved for future use.
3.	**External Sync Input:** TTL input that has a 10 kΩ pullup resistor. Allows data acquisition and readout to be synchronized with external events. Through software, either positive or negative (default) edge triggering can be selected.
4.	$\overline{\text{SCAN}}$ **Output** WinView/32 (ver. 2.4 and higher) software selectable NOT SCAN or SHUTTER signal. Default is SHUTTER. $\overline{\text{SCAN}}$, reports when the controller is finished reading out the CCD array. $\overline{\text{SCAN}}$ is high when the CCD array is not being scanned, then drops low when readout begins, returning to high when the process is finished. The second signal, SHUTTER, reports when the shutter is opened and can be used to synchronize external shutters. SHUTTER is low when the shutter is closed and goes high when the shutter is activated, dropping low again after the shutter closes. See Figure 4 for timing diagram.
5.	READY **Output:** Initially HIGH. After a Start Acquisition command, this output changes state on completion of the array cleaning cycles that precede the *first* exposure. Initially high, it goes low to mark the beginning of the *first* exposure. In free run operation it remains low until the system is halted. If a specific number of frames have been programmed, it remains low until all have been taken, then returns high.
6.	**Zero Adjustment:** Control the offset values of the Fast (F) and Slow (S) A/D converters. Preadjusted at factory. The offset is a voltage that is added to the signal to bring the A/D output to a non-zero value, typically 50-100 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the A/D "0" value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 (16-bit A/D) to a value in the range of 50-100 counts lower. **Caution:** Do not adjust the offset values to zero, or some low-level data will be missed.
7.	**Detector Connector:** Transmits control information to the camera and receives data back from the camera via the Detector-Controller cable.
8.	**TTL In/Out:** User-programmable interface with eight input bits and eight output bits that can be written to or polled for additional control or functionality. Under USB 2.0, output is not currently supported in WinView. See Chapter 6.
9.	**AUX Output:** Reserved for future use.
10.	**Serial COM Connector:** Provides two-way serial communication between the controller and the host computer. Contact the factory if an application requires use of the optional fiberoptic data link to increase the maximum allowable distance between the Camera and the computer.
11.	**Fan:** Cools the controller electronics. Runs continuously when the controller is turned on. Do not block the side vents or the fan exhaust port.

#	Feature
12.	**Shutter Setting Selector:** Sets the shutter hold voltage. Contact factory for the correct shutter setting for a remote x-ray shutter.
13.	**Remote Shutter Connector:** Provides shutter-drive and hold voltages for a Princeton Instruments 25 mm external shutter (typically, an entrance slit shutter). May be used for a remote x-ray shutter. **WARNING:** Dangerous live potentials are present at the **Remote** Shutter Power connector. To avoid shock hazard, the Controller power should be OFF when connecting or disconnecting a remote shutter.
14.	**Power Input Module:** Contains the power cord socket and two fuses. Depending on the ST-133 version, the power switch may be located directly above the power module.
15.	**Fuse/Voltage Label:** Displays the controller's power and fuse requirements. This label may appear below the power module.
16.	**USB 2.0 Connector:** Provides two-way serial communication between the controller and the host computer. Uses USB 2.0 protocol.



t_{exp} = Exposure Time
t_R = Readout Time
t_c = Shutter Compensation Time

Shutter Type	Compensation Time
NONE	200 nsec
Electronic	6.0 msec
Remote (Roper Scientific 23 mm, External, typically a slit shutter)	8.0 msec
Small (Roper Scientific 25 mm, Internal)	8.0 msec
Large (Roper Scientific 35/40 mm, External)	28.0 msec

Figure 4. NOT SCAN and SHUTTER Signals

Cables

Detector-Controller: 1 MHz or 100kHz/1MHz systems. The standard 10' cable (6050-0484) has DB-25 Male connectors with slide-latch locking hardware. This cable interconnects the Detector connector on the rear of the ST-133 with the 25-pin D connector on the back of the PI-SCX camera. The Detector-Controller cable is also available in 6', 15', 20', and 30' lengths. Note that a longer cable may degrade camera performance.

Computer Interface Cable: Depending on the system configuration, either a USB or a TAXI cable will be shipped.

TAXI: The standard 25' (7.6 m) cable (6050-0148-CE) has DB-9 Male connectors with screw-down locking hardware. The TAXI (Serial communication) cable interconnects the **Serial Com** connector on the rear of the ST-133 with the PCI card installed in the host computer. In addition to the standard length, this cable is available in 10', 50', 100', and 165' lengths. Also available are fiber optic adapters with fiber optic cables in 100, 300, and 1000 meter lengths.

USB 2.0: The standard 16.4' (5 m) cable (6050-0494) has USB connectors that interconnect the **USB 2.0** connector on the rear of the ST-133 with a USB card installed in the host computer.

Interface Card

PCI Card: This interface card is required when the system interface uses the TAXI protocol rather than USB 2.0. The PCI card plugs-into the host computer's motherboard and provides the serial communication interface between the host computer and the ST-133. Through WinView/32 or WinSpec/32, the card can be used in either **High Speed PCI** or **PCI(Timer)** mode. **High Speed PCI** allows data transfer to be interrupt-driven and can give higher performance in some situations. **PCI(Timer)** allows data transfer to be controlled by a polling timer.

USB 2.0 Card: This interface card is required when the system interface uses the USB 2.0 protocol rather the TAXI protocol and the computer does not have native USB 2.0 support. The USB 2.0 card plugs-into the host computer's motherboard and provides the communication interface between the host computer and the ST-133. The USB 2.0 PCI card (70USB90011) by Orange Micro is recommended for desktop computers; the SIIG, Inc. USB 2.0 PC Card, Model US2246 is recommended for laptop computers. See www.orangemicro.com or www.siig.com, respectively, for more information.

Application Software

The Princeton Instruments WinView/32 software package provides comprehensive image acquisition, display, processing, and archiving functions so you can perform complete data acquisition and analysis without having to rely upon third-party software. WinView/32 provides reliable control over all Princeton Instruments cameras, regardless of array format and architecture, via an exclusive universal programming interface (PVCAM®). WinView/32 also features snap-ins and macro record functions to permit easy user customization of any function or sequence.

PVCAM is the standard software interface for cooled CCD cameras from Princeton Instruments. It is a library of functions that can be used to control and acquire data from the camera when a custom application is being written. For example, in the case of Windows, PVCAM is a dynamic link library (DLL). Also, it should be understood that PVCAM is solely for camera control and image acquisition, not for image processing. PVCAM places acquired images into a buffer, where they can then be manipulated using either custom written code or by extensions to other commercially available image processing packages.

Scientific Imaging ToolKit™ (SITK™) is a collection of LabVIEW® VIs for scientific cameras and spectrographs. This third party software can be purchased from Princeton Instruments.

User Manuals

PI-SCX System User Manual: This manual describes how to install and use the PI-SCX system components.

WinView/32 User Manual: This manual describes how to install and use the application program. A PDF version of this manual is provided on the installation CD. Additional information is available in the program's on-line help.

Note: You can download current versions of Princeton Instruments manuals at ftp://ftp.princetoninstruments.com/Public/Manuals/Princeton Instruments/. Versions of Acton manuals are located at ftp://ftp.princetoninstruments.com/Public/Manuals/Acton/.

Chapter 3
Installation Overview

The list and diagrams below briefly describe the sequence of actions required to hookup your system and prepare to gather data. Refer to the indicated references for more detailed information. This list assumes that the application software is Princeton Instruments WinView/32.

Action	Reference
1. If the system components have not already been unpacked, unpack them and inspect their carton(s) and the system components for in-transit damage. Store the packing materials.	Chapter 4 System Setup, page 25
2. Verify that all system components have been received.	Chapter 4 System Setup, page 25
3. If the components show no signs of damage, verify that the appropriate voltage settings have been selected for the Controller.	Chapter 4 System Setup, page 28
4. If the WinView/32 software is not already installed in the host computer, install it. This will install the appropriate drivers for the interface card.	WinView/32 manual
5. If the appropriate interface card is not already installed in the host computer, install it.	Chapter 4 System Setup, PCI Interface, page 31 or USB 2.0 Interface, page 32
6. With the Controller and computer power turned **OFF**, connect the interface cable (TAXI or USB) to the Controller and the interface card in the host computer. Then tighten down the locking hardware.	Chapter 4 System Setup, page 35
7. With the Controller power turned **OFF**, connect the Detector-Controller cable to the appropriate connector on the rear of the **Controller** and the other end to the appropriate connector on the rear of the **Camera**. Adjust the slide latches so the cable connections are locked.	Chapter 4 System Setup, page 35 Chapter 7, Troubleshooting, page 82
8. With the Controller power turned **OFF**, connect the Controller power cable to the rear of the controller and to the power source.	
9. If the camera has water-assisted cooling or is water-cooled, make the tubing connections between the circulator and the camera. Fill the circulator with the required mixture, turn on the circulator, turn on the refrigeration, and set the coolant temperature.	Chapter 4 System Setup, page 37 Chapter 5 Operation, page 43
10. Turn the Controller **ON**.	

Action	Reference
11. Turn on the computer and begin running WinView/32. When the computer boots, you may be asked for the location of the interface drivers.	Chapter 4 System Setup, page 31 (PCI drivers) or page 32 (USB drivers) WinView/32 manual
12. Enter the hardware setup information or load the defaults from the controller.	Chapter 5 Operation, page 43
13. Set the target array temperature.	Chapter 5 Operation, page 43
14. When the system reaches temperature lock, begin acquiring data in focus mode.	Chapter 5 Operation, page 45

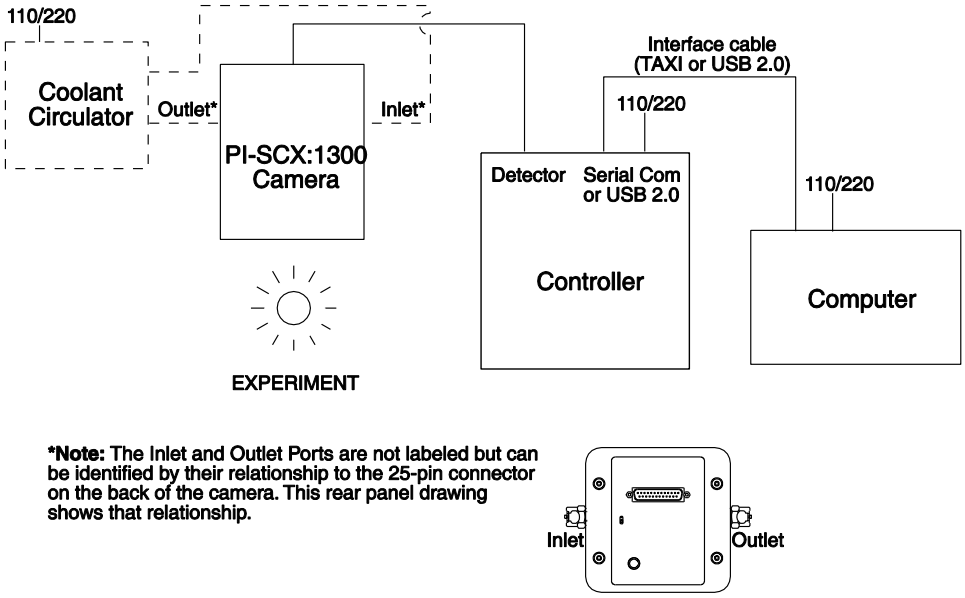


Figure 5. PI-SCX:1300 System Diagram

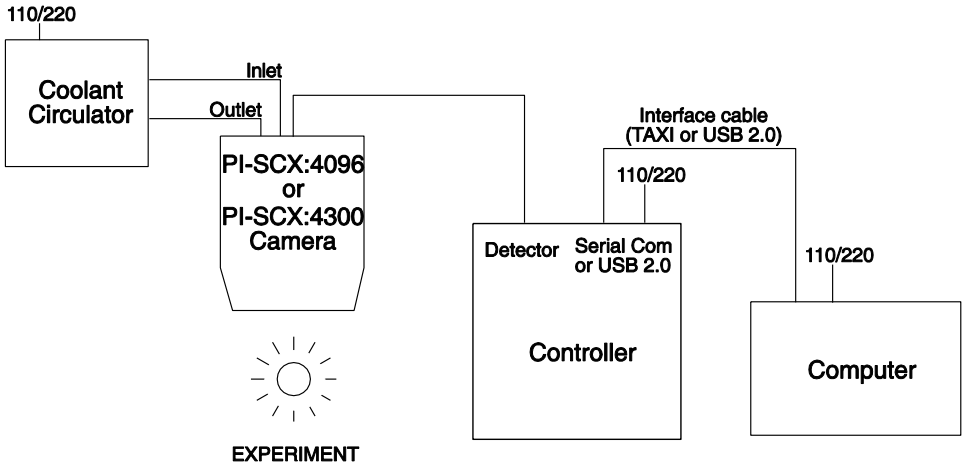


Figure 6. PI-SCX:4096 and PI-SCX:4300 System Diagram

Chapter 4
System Setup

Unpacking the System

During the unpacking, check the system components for possible signs of shipping damage. If there are any, notify Princeton Instruments and file a claim with the carrier. If damage is not apparent but camera or controller specifications cannot be achieved, internal damage may have occurred in shipment. Please save the original packing materials so you can safely ship the camera system to another location or return it to Princeton Instruments for repairs if necessary.

Checking the Equipment and Parts Inventory

Confirm that you have all of the equipment and parts required to set up the system. A complete PI-SCX system consists of

- **Camera:** PI-SCX:1300, PI-SCX:4096, or PI-SCX:4300.
- **ST-133 Controller:** Do not substitute any other controller for the controller supplied with your system.
- **Camera to Controller cable:** DB25 to DB25, 10 ft (6050-0484).
- **Controller to Computer cable:**
  - TAXI cable: DB9 to DB9 cable (6050-0148-CE is standard) or
  - USB cable: Five (5) meter cable (6050-0494) is standard
- **Interface Board: PCI or USB 2.0**
  - Proprietary Princeton Instruments (RSPI) High Speed PCI Interface board for TAXI interface.
  - USB 2.0 board for USB 2.0 interface is user-provided: native USB 2.0 support on the motherboard or USB 2.0 Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop; SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop).
- **WinView/32 CD-ROM:** This CD contains the WinView/32 imaging software and related manuals in PDF format.
- **User Manuals**: PI-SCX System and WinView/32 Imaging Software. These manuals are supplied on the CD shipped with your system.
- **Host Computer:** Typically, the computer is user-supplied.
- **Coolant Circulator:** Not required by some systems. Typically, the coolant circulator and hoses are user-supplied.

System Requirements

Environmental

Operating temperature: 0ºC to +30ºC;

Operating temperature range over which system specifications can be met: +18ºC to +23ºC

Relative humidity <50% noncondensing.

Ventilation

Camera: Allow at least one inch of clearance for side and rear air vents.

ST-133: There is an internal fan located at the right side of the rear panel behind an exhaust opening. Its purpose is simply to cool the controller electronics. This fan runs continuously whenever the controller is powered. Air enters the unit through ventilation openings on the side panels, flows past the warm electronic components as it rises, and is drawn out the rear of the controller by the fan. It is important that there be an adequate airflow for proper functioning. As long as both the controller's intake ventilation openings and the fan exhaust opening aren't obstructed, the controller will remain quite cool.

Vacuum

The CCD is housed in the vacuum with the fiberoptic taper extending beyond the vacuum chamber with a thin Beryllium window to block visible light and to admit X-rays. The camera is shipped with a vacuum quality superior to the minimum required to assure proper operation of the system for an extended period of time without concern for the quality of the vacuum. *See Appendix C for additional information.*

Coolant

WARNING!

COOLANT IS HARMFUL IF SWALLOWED.

KEEP OUT OF REACH OF CHILDREN.

PI-SCX cameras with water-assisted cooling or water-only cooling require circulating coolant (50:50 mixture of ethylene glycol and water) for proper operation. All hose connections should be secured with good quality hose clamps.

Flow Rate: Users are advised to install a flow meter to monitor the rate.

PI-SCX:1300 > 1 liter/minute.

PI-SCX:4096 3 liters/minute (minimum).

PI-SCX:4300 3 liters/minute (minimum).

Fluid Pressure: 25 psig (maximum).

Inlet/Outlet Port Locations:

PI-SCX:1300 Two quick-disconnect coolant ports are supplied with a water-cooled system and are mounted at the sides of the camera. For the best cooling, make the hose connections to the Inlet and Outlet ports as shown in the outline drawing on page 38. Use 1/4" thin-wall tubing.

PI-SCX:4096 and PI-SCX:4300 Two barbed 3/8″ O.D. coolant ports are located at the back of the camera. Either port can be the inlet or the outlet. 3/8" ID Tygon tubing is suitable.

Caution **Coolant Temperature:** Coolant should be no colder than the following temperatures:

PI-SCX:1300 +25°C. Operating a PI-SCX:1300 camera with coolant at a colder temperature could cause induced condensation in the electronics enclosure and possible catastrophic damage to the camera. ***Damage resulting from this type of operation may void the warranty.***

PI-SCX:4096 +5°C for tapers with ≤ 1.5:1 fiber ratio; +0°C for tapers with >1.5:1 fiber ratio.

PI-SCX:4300 +5°C.

Power

Camera: The PI-SCX camera receives its power from the controller, which in turn plugs into a source of AC power.

ST-133: The ST-133 Controller can operate from any one of four different nominal line voltages: 100, 120, 220, or 240 V AC. Refer to the Fuse/Voltage label on the back of the ST-133 for fuse, voltage, and power consumption information.

Caution The plug on the line cord supplied with the system should be compatible with the line-voltage outlets in common use in the region to which the system is shipped. If the line cord plug is incompatible, a compatible plug should be installed, taking care to maintain the proper polarity to protect the equipment and assure user safety.

Host Computer

Note: Computers and operating systems all undergo frequent revision. The following information is only intended to give an approximate indication of the computer requirements. Please contact the factory to determine your specific needs.

Requirements for the host computer depend on the type of interface, TAXI or USB 2.0, that will be used for communication between the ST-133 and the host computer. Those requirements are a listed below according to protocol.

TAXI Protocol:

- AT-compatible computer with 200 MHz Pentium® II (or better).
- Windows® XP (32-bit, SP3 or later) or Vista® (32-bit) operating system.
- Princeton Instruments (RSPI) High speed serial PCI card (or an unused PCI card slot). Computers purchased from Princeton Instruments are shipped with the PCI card installed if High speed PCI was ordered.
- Minimum of 256 Mbytes of RAM.
- CD-ROM drive.
- Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes and the remainder is required for data storage, depending on the number and size of spectra collected. Disk level compression programs are not recommended.

- Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory requirement is dependent on desired display resolution.
- Two-button Microsoft®-compatible serial mouse or Logitech® three-button serial/bus mouse.

- **USB 2.0 Protocol:**
  - AT-compatible computer with Pentium 3 or better processor and runs at 1 GHz or better.
  - Windows® XP (32-bit, SP3 or later) or Vista® (32-bit).
  - Native USB 2.0 support on the mother board or USB Interface Card (Orange Micro 70USB90011 USB2.0 PCI is recommended for desktop; SIIG, Inc. USB 2.0 PC Card, Model US2246 for laptop)
  - Minimum of 256 Mbytes of RAM.
  - CD-ROM drive.
  - Hard disk with a minimum of 80 Mbytes available. A complete installation of the program files takes about 17 Mbytes and the remainder is required for data storage, depending on the number and size of spectra collected. Disk level compression programs are not recommended.
  - Super VGA monitor and graphics card supporting at least 256 colors with at least 1 Mbyte of memory. Memory requirement is dependent on desired display resolution.
  - Two-button Microsoft compatible serial mouse or Logitech three-button serial/bus mouse.

Verifying Controller Voltage Setting

The Power Input Module on the rear of the Controller contains the voltage selector drum, fuses and the power cord connector. The appropriate voltage setting is set at the factory and can be seen on the power input module.

Each setting actually defines a range and the setting that is closest to the actual line voltage should have been selected. The fuse and power requirements are printed on the panel above the power input module. The correct fuses for the country where the ST-133 is to be shipped are installed at the factory.

Note: On ST-133s, the voltage ranges and fuse ratings may be printed above or below the power module (Figure 7).

Figure 7. Controller Power Input Module

To Check the Controller's Voltage Setting:

1. Look at the lower righthand corner on the rear of the Controller. The current voltage setting (100, 120, 220, or 240 VAC) is displayed on the Power Input Module.
2. If the setting is correct, continue with the installation. If it is not correct, follow the instructions on page 67 for changing the ST-133 Controller's voltage setting and fuses.

Mounting the Camera

PI-SCX:1300 This camera head style is available with a tripod adapter option with three mounting holes (1/4"-20, 3/8"-16, and M6). Figure 8 shows the adapter mounted to the bottom of the camera.

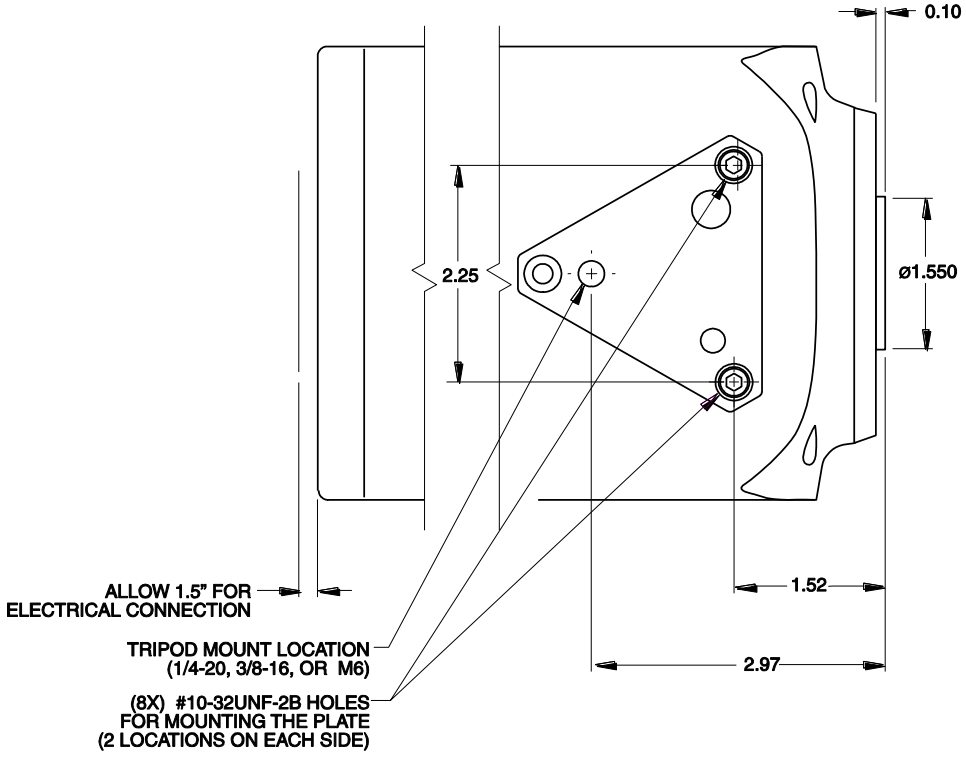


Figure 8. Mounting Holes on Tripod Adapter

PI-SCX:4300 On the bottom of the camera towards the rear are three threaded holes that can be used to mount the camera. Two of the holes are M8 × 1.25 tap (25 mm deep) and the third one is 1/4″–20 tap (0.5″ deep). Figure 9 shows the location of the mounting holes and their distance from the back of the camera.

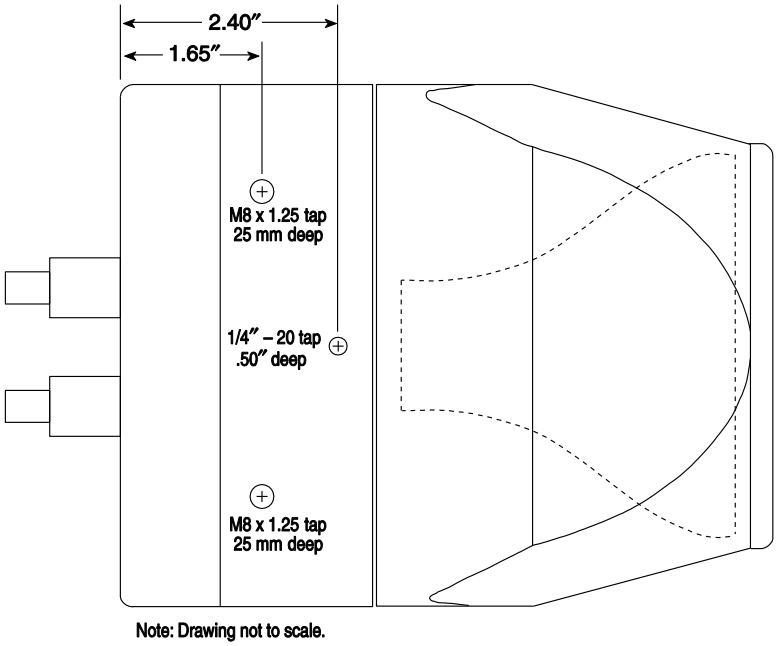


Figure 9. Mounting Holes on Bottom of Camera

Installing the Application Software

Installation is performed via the WinView/32 installation process. If you are installing WinView for the first time, you should run the installation before the interface card is installed in the host computer. On the **Select Components** dialog (see Figure 10), click on the **AUTO PCI** button to install the interface card drivers (the Princeton Instruments PCI and the USB drivers) and the most commonly installed program files. Select the **Custom** button if you would like to choose among the available program files or do not want to install the PCI driver.

Figure 10. WinView Installation: Interface Card Driver Selection

Note: WinView/32 and WinSpec/32 (versions 2.6.0 and higher) do not support the ISA interface.

Setting up the Communication Interface

PI-SCX camera systems require either an installed Princeton Instruments (RSPI) PCI card or an installed USB2.0 interface card in the host computer. The type of interface card is dictated by the Interface Control Module installed in the ST-133 controller.

Setting up a PCI Interface

Administrator privileges are required under Windows® XP and Windows Vista® (32-bit) to install software and hardware.

A Princeton Instruments (RSPI) PCI card must be installed in the host computer if the communication between computer and controller uses the TAXI protocol (i.e., the **Interface Control Module** installed in the ST-133 has a 9-pin **SERIAL COM** connector as shown in the figure at right). With TAXI protocol, the standard cable provided with an ST-133 is 7.6 meters (25 feet). Cable lengths up to 50 meters (164 feet) are available and the digitization rate may be as high as 2 MHz.

A computer purchased from Princeton Instruments will be shipped with the PCI card already installed. Otherwise, a PCI card will be shipped with the system and you will have to install it in the host computer at your location.

Note: The PCI card can be installed and operated in any Macintosh having a PCI bus, allowing the ST-133 to be controlled from the Macintosh via IPLab™ software and the PI Extension.

Caution If using WinX software, select either **High Speed PCI** or **PCI(Timer)** as the Interface type. This selection is accessed on the Hardware **Setup|Interface** tab**. High Speed PCI** allows data transfer to be interrupt-driven and gives the highest performance in some situations. **PCI(Timer)** allows data transfer to be controlled by a polling timer. This selection is recommended when there are multiple devices sharing the same interrupt.

To Install a PCI Serial Buffer Card in the Host Computer:

1. Review the documentation for your computer and PCI card before continuing with this installation.
2. To avoid risk of dangerous electrical shock and damage to the computer, verify that the computer power is OFF.
3. Remove the computer cover and verify that there is an available PCI slot.
4. Install the PCI card in the slot.
5. Make sure that the card is firmly seated and secure it.
6. Replace and secure the computer cover and turn on the computer only. If an error occurs at bootup, either the PCI card was not installed properly or there is an address or interrupt conflict. Refer to Chapter 9 "Troubleshooting", page 76 for instructions.

Note: The PCI card has no user-changeable jumpers or switches.

To Install the PCI Card Driver

The following information assumes that you have already installed the WinView/32 or WinSpec/32 software.

1. After you have secured the PCI card in the computer and replaced the cover, turn the computer on.
2. At bootup, Windows will try to install the new hardware. If it cannot locate the driver, you will be prompted to enter the directory path, either by keyboard entry or by using the browse function.

   If you selected **AUTO PCI** during the application software installation, WinView/32 or WinSpec/32 automatically put the required INF file into the Windows\Inf directory and the PCI card driver file is copied into the Windows\System32\ Drivers directory. Refer to Table 1 for the appropriate file names and locations.

Windows Version	PCI INF Filename Located in "Windows"\Inf directory*	PCI Device Driver Name Located in "Windows"\System32\Drivers directory
Windows® XP and Windows Vista® (32-bit)	rspi.inf (in Windows\inf, for example)	rspipci.sys (in Windows\System32\Drivers, for example)

* The INF directory may be hidden.

Table 1. PCI Driver Files and Locations

Setting up a USB 2.0 Interface

Administrator privileges are required under Windows® XP and Windows Vista® (32-bit) to install software and hardware.

Your system has been configured to use the USB communication protocol if the **Interface Control Module** installed in the ST-133 has a **USB 2.0** connector as shown in the figure at right). The advantages to the USB 2.0 interface are that it uses a much higher data transfer rate than many common serial data formats (such as the TAXI protocol) and it simplifies the connection to external devices. USB supports "plug and play" -- you do not need to be heavily involved in the setup process.

USB 2.0 Limitations

- Maximum cable length is 5 meters (16.4 feet)
- 1 MHz is currently the upper digitization rate limit for the ST-133 Controller. Large data sets and/or long acquisition times may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (Easy DLLS).
- Some WinView and WinSpec 2.5.X features are not fully supported with USB 2.0. Refer to Appendix D, page 101, for more information.

Note: If you are installing the USB 2.0 interface on a laptop, you will need to perform all of the operations described in this section. In addition, if you are using the recommended USB Interface Card (SIIG, Inc. USB 2.0 PC Card, Model US2246), you must replace the OrangeUSB USB 2.0 Host Controller driver installed for that card with the appropriate

Microsoft driver. Instructions for making the replacement are included in ***"To Update the OrangeUSB USB 2.0 Driver"***.

To Update the OrangeUSB USB 2.0 Driver:

This procedure is highly recommended when a laptop computer will be used to communicate with the ST-133. As stated before, we recommend the SIIG, Inc. USB 2.0 PC Card, Model US2246 if USB 2.0 is not native to the laptop's motherboard. To reduce the instances of data overruns and serial violations, the OrangeUSB USB 2.0 Host Controller installed for the SIIG card, should be replaced by the appropriate Microsoft driver (Windows XP or Windows Vista, depending on the laptop's operating system.)

Note: This procedure may also be performed for desktop computers that use the Orange Micro 70USB90011 USB2.0 PCI.

1. Download and install Microsoft Service Pack 3 (for Windows XP) if the service pack has not been installed.
2. From the Windows **Start** menu, select **Settings|Control Panel**.
3. Select **System** and then **System Properties**.
4. Select the **Hardware** tab and click on **Device Manager** button.
5. Expand **Universal Serial Bus Controllers**.
6. Right-mouse click on **OrangeUSB USB 2.0 Host Controller** and select **Properties**.
7. On the **Driver** tab, click on the **Update Driver…** button. You may have to wait a minute or so before you will be allowed to click on the button.
8. When the **Upgrade Device Driver wizard** appears, click on **Next**. Select the **Search for a suitable driver …** radio button.
9. On the next screen select the **Specify a location** checkbox.
10. Browse and select the location. Click on **OK**.
11. In the **Driver Files Search Results** window, check the **Install one of the other drivers** check box.
12. Select the **NEC PCI to USB Enhanced Host Controller B1** driver. Click on **Next** and the installation will take place. When the **Completing the Upgrade Device Driver wizard** window appears, click on **Finish**. You will then be given the choice of restarting the computer now or later. According to the window text, the hardware associated with the driver will not work until you restart the computer.

To Install the Princeton Instruments USB2 Interface:

The following information assumes that:

- You have verified that the host computer meets the required specifications for USB 2.0 communication with the PI-SCX system (see page 28).
- A USB 2.0 board and its driver are installed in the host computer.
- The ST-133 has an installed USB 2.0 Interface Control module.
- You have already installed the WinX software (versions 2.5.15 and higher). Versions 2.5.15 and higher automatically install the driver and INF files required to support the USB 2.0 Interface Control module.

1. Before installing the Princeton Instruments USB2 Interface, we recommend that you defragment the host computer's hard disk. This operation reduces the time the computer spends locating files. Typically, the "defrag" utility "Disk Defragmenter" can be accessed from the Windows® Start menu and can usually accessed from the Programs/Accessories/System Tools subdirectory.
2. After defragmenting the hard disk, turn off the computer and make the USB cable connections between the host computer and the ST-133. Then, turn the ST-133 on before turning on the host computer.
3. At bootup, Windows will detect the Princeton Instruments USB2 Interface hardware (i.e., the USB 2.0 Interface Control module). You may be prompted to enter the directory path(s) for the apausbprop.dll and/or the apausb.sys file(s), either by keyboard entry or by using the browse function.

   If you selected **AUTO PCI** during the application software installation, WinX automatically put the required INF, DLL, and USB driver file in the "Windows" directories shown below. Refer to the Table 2 for the file locations.

Windows Version	USB INF Filename Located in "Windows"\Inf directory*	USB Properties DLL Located in "Windows"\System32 directory	USB Device Driver Name Located in "Windows"\System32\Drivers directory
Windows® XP and Windows Vista® (32-bit)	rsusb2k.inf (in Windows.inf, for example)	apausbprop.dll (in Windows\System32, for example)	apausb.sys (in Windows\System32\Drivers, for example)

* The INF directory may be hidden.

Table 2. USB Driver Files and Locations

Connecting the Interface (Controller-Computer) Cable

TAXI® Cable (6050-0148-CE)

Caution Turn the Controller power OFF (OFF = 0, ON = |) and the Computer power OFF before connecting or disconnecting the Controller-Computer (TAXI) cable.

To Connect the TAXI Cable:

1. Verify that the Controller power is OFF.
2. Verify that the Computer power is OFF.
3. Connect one end of the TAXI cable to the 9-pin port on the Interface card in the host computer.
4. Tighten down the screws to lock the connector in place.
5. Connect the other end of the cable to the "Serial Com" port on the rear of the Controller.
6. Tighten down the screws to lock the connector in place.

USB 2.0 Cable (6050-0494)

Caution Turn the Controller power OFF (OFF = 0, ON = |) and the Computer power OFF before connecting or disconnecting the Controller-Computer (TAXI) cable.

To Connect the USB 2.0 Cable:

1. Verify that the Controller power is OFF.
2. Verify that the Computer power is OFF.
3. Connect one end of the USB cable to the USB port on the host computer.
4. Connect the other end of the cable to the USB 2.0 port on the rear of the Controller.

Connecting the Camera-Controller Cable

Caution Turn the Controller power OFF (OFF = 0, ON = |) before connecting or disconnecting the Camera-Controller cable.

To Connect the Camera-Controller Cable (6050-0484):

1. Verify that the Controller power is OFF.
2. Connect male end of the Camera-Controller cable to the "Detector" port on the back of the Controller.
3. Move the slide latch over to lock the connector in place.
4. Connect the female end of the cable to the Camera.
5. Move the slide latch over to lock the connector in place.

Entering the Default Camera System Parameters into WinX (WinView/32, WinSpec/32, or WinXTest/32)

Software changes implemented in WinX version 2.15.9.6 affected the way in which default parameters were entered for camera systems. Therefore, two sets of instructions are included. Follow the instructions appropriate to the software version that you installed. Note that these instructions assume that you have performed the computer interface installation.

WinX Versions 2.5.19.6 and later

1. Make sure the ST-133 is connected to the host computer and that it is turned on.
2. Run the WinX application. The **Camera Detection wizard** will automatically run if this is the first time you have installed a Princeton Instruments WinX application (WinView/32, WinSpec/32, or WinXTest/32) and a supported camera. Otherwise, if you installing a new camera type, click on the **Launch Camera Detection Wizard…** button on the **Controller/CCD** tab to start the wizard.
3. On the **Welcome** dialog (Figure 11), leave the checkbox unselected and click on **Next**.

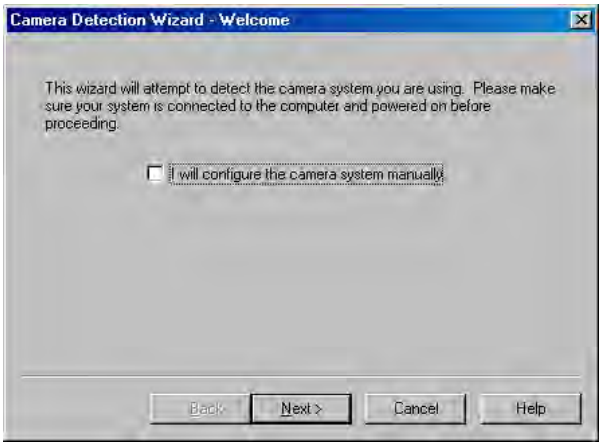

Camera Detection Wizard - Welcome
This wizard will attempt to detect the camera system you are using. Please make sure your system is connected to the computer and powered on before proceeding.
I will configure the camera system manually
Back
Next >
Cancel
Help

Figure 11. Camera Detection Wizard - Welcome dialog

4. Follow the instructions on the dialogs to perform the initial hardware setup: this wizard enters default parameters on the Hardware Setup dialog tabs and gives you an opportunity to acquire a test image to confirm the system is working.

WinX Versions before 2.5.19.6: Run RSConfig.exe

1. Make sure the ST-133 is connected to the host computer and that it is turned on.
2. Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed WinView, WinSpec, or WinXTest.
3. When the RSConfig dialog (Figure 12) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

Note: If the first camera in the list is not the "Princeton Style (USB2)", you will need to edit the PVCAM.INI file created by RSConfig. See the instructions in ***"Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)",*** page 73.

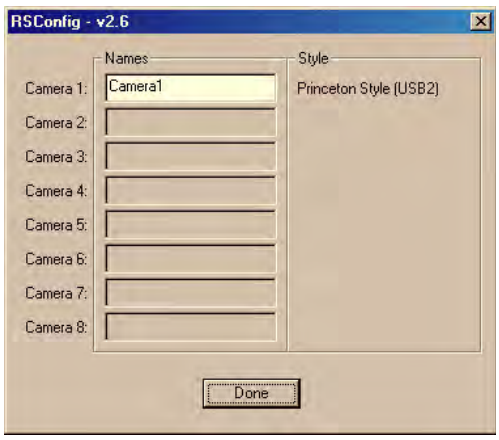


Figure 12. RSConfig dialog

4. Open the WinX application and, from **Setup|Hardware…,** run the Hardware Setup wizard.
5. When the PVCAM dialog (Figure 13) is displayed, click in the **Yes** radio button, click on **Next** and continue through the wizard. After the wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to set up experiments and acquire data.

Figure 13. Hardware Setup wizard: PVCAM dialog

6. Run the software in focus mode to verify communication between the ST-133 and the host computer.

Making the Circulator-Camera Connections

1. Set up the coolant circulator according to the directions in the user manual for that equipment. Do not apply power to the circulator until directed to do so.
2. Make the hose connections between the circulator and the camera. For best cooling performance, the tubing should be no longer than necessary.
   - **PI-SCX:1300** Use 1/4", thin-wall plastic tubing. Be sure the tubing is properly secured at both ends. Note that the ports on this camera use a ferrule-less quick-disconnect method of securing the tubing and that both the camera's valve body and the fitting insert include automatic shutoff to prevent coolant leaks when disconnected. ***For best cooling, connect the inflow and outflow tubing to the ports as indicated in*** *Figure 14****.***

To Secure the Tubing:

a. Remove the retaining nuts for the fitting and slide them over the outside of the plastic tubing.

b. Slide the tubing over the barb on the fitting.

c. Slide the retaining nuts to the end of the tubing and tighten them to the threads of the fitting.

d. Insert the fitting into the appropriate valve body (Inlet or Outlet) until it clicks.

Because of the automatic shutoffs, disconnecting the coolant supply is done by simply depressing the release tabs (Figure 14) and removing the fittings. Reconnecting the supply is done by reinserting each fitting into the appropriate valve body until you hear a click.

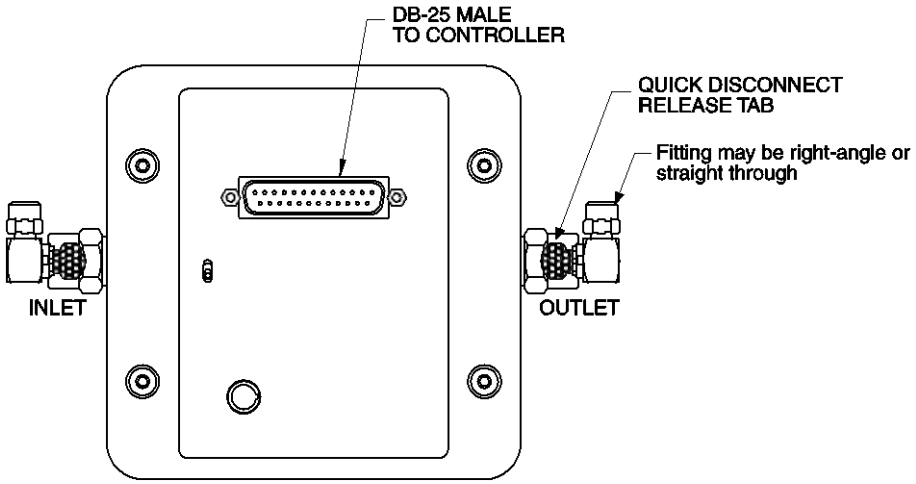
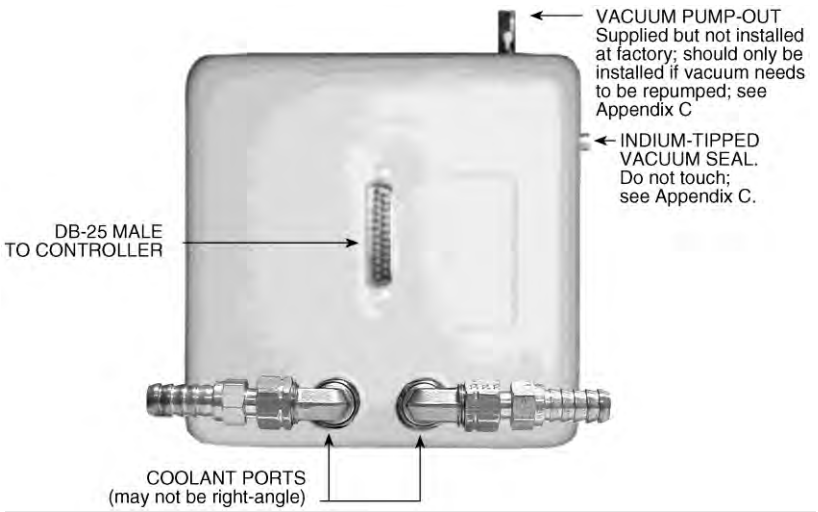


Figure 14. PI-SCX:1300 Camera Back Panel

- **PI-SCX:4300** Use 3/8″ I.D. plastic tubing. Be sure the tubing is properly secured with hose clamps at both ends. Note that either of the camera's coolant ports can function as the inlet or outlet. We advise installing an in-line flow meter so that the flow rate can be monitored.
- **PI-SCX:4096** Use 3/8″ I.D. plastic tubing. Be sure the tubing is properly secured with hose clamps at both ends. Note that either of the camera's coolant ports can function as the inlet or outlet. We advise installing an in-line flow meter so that the flow rate can be monitored.


VACUUM PUMP-OUT
Supplied but not installed at factory; should only be installed if vacuum needs to be repumped; see Appendix C
INDIUM-TIPPED VACUUM SEAL. Do not touch; see Appendix C.
DB-25 MALE TO CONTROLLER
COOLANT PORTS (may not be right-angle)

Note: Systems are now shipped with fittings that allow you to select either a right angle or straight port configuration.

Figure 15. PI-SCX:4300 and PI-SCX:4096 Camera Back Panel

Caution Do not disturb the Vacuum Pumping fitting or the Indium-tipped Vacuum Seal on the PI-SCX:4300. Damage to the vacuum fittings and seals could void your warranty. Refer servicing to qualified personnel and contact the factory Customer Support for guidance. Detailed information about the vacuum system is provided in Appendix C.

3. Fill the circulator with a mixture of 50% ethylene glycol and 50% water.

Service Notes

There are no user-serviceable components inside the ST-133 or the fiberoptic taper camera. Refer servicing to qualified personnel and contact the factory Customer Support for guidance. Contact information is provided in the ***Warranty & Service*** section of the manual.

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Chapter 5
Operation

Introduction

Once the PI-SCX camera has been installed, camera operation is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32 or WinSpec/32), set the target detector temperature, wait until the temperature has stabilized at the set temperature (see the "Setting the Temperature" section in this chapter), and then do actual data acquisition in the **Acquire** mode. Additional considerations regarding experiment setup and equipment configuration are addressed in the software manual.

During data acquisition, the CCD array is exposed to a source and charge accumulates in the pixels. After the defined exposure time, the accumulated signal is readout of the array, digitized, and then transferred to the host computer. Upon data transfer, the data is data is displayed and/or stored via the application software. This sequence is illustrated by the block diagram shown in Figure 16.

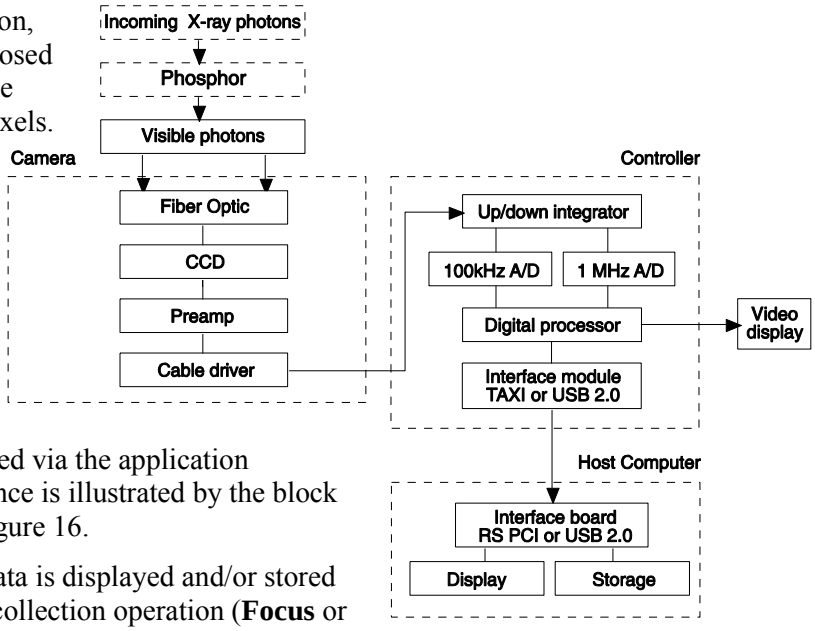


Figure 16. Block Diagram of Light Path in System

Whether or not the data is displayed and/or stored depends on the data collection operation (**Focus** or **Acquire**) that has been selected in the application software. In WinView and WinSpec, these operations use the Experiment Setup parameters to establish the exposure time (the period when signal of interest is allowed to accumulate on the CCD). As might be inferred from the names, **Focus** is more likely to be used in setting up the system (see the ***"First Light"*** discussions) and **Acquire** is then used for the collection and storage of data. Briefly:

- In **Focus** mode, the number of frames and accumulations settings are ignored. A single frame is acquired and displayed, another frame is acquired and overwrites the currently displayed data, and so on until Stop is selected. Only the last frame acquired before Stop is selected can be stored. When Stop is selected, the File Save function can be used to save the currently displayed data. This mode is particularly convenient for familiarization and setting up. For ease in focusing, the screen refresh rate should be as rapid as possible, achieved by operating with axes and cross-sections off, and with Zoom 1:1 selected.

- In **Acquire** mode, every frame of data collected can be automatically stored (the completed dataset may include multiple frames with one or more accumulations). This mode would ordinarily be selected during actual data collection. One limitation of Acquire mode operation is that if data acquisition continues at too fast a rate for it to be stored, data overflow will eventually occur. This could only happen in Fast Mode operation.

The remainder of this chapter is organized to first talk about the system on/off sequences. Then "First Light" procedures for imaging and spectroscopy applications follow: these procedures provide step-by-step instruction on how to initially verify system operation. The last three sections discuss factors that affect exposure, readout, and digitization of the incoming signal. By understanding these factors and making adjustments to software settings you can maximize signal-to-noise ratio. For information about synchronizing data acquisition with external devices, please refer to ***Chapter 6, Advanced Topics***.

System On/Off Sequences

If your system is configured for the USB 2.0 communication interface, you must follow the system on/off sequences as stated below. These sequences ensure that communication is established and maintained between the camera and the host computer:

1. The PI-SCX camera must be powered ON before WinView/32 or WinSpec/32 is opened to ensure communication between the camera and the computer. If WinView or WinSpec is opened and the PI-SCX is not powered ON, many of the functions will be disabled and you will only be able to retrieve and examine previously acquired and stored data. You must close WinView or WinSpec, power the camera ON, and reopen WinView or WinSpec before you can set up experiments and acquire new data.
2. WinView/32 or WinSpec/32 must be closed before powering the camera OFF. If you power the camera OFF before closing WinView or WinSpec, the communication link with the camera will be broken. You can operate the program in a playback mode (i.e., examine previously acquired data) but will be unable to acquire new data until you have closed WinView or WinSpec, powered the camera ON, and then re-opened WinView or WinSpec.

First Light

The following paragraphs provide step-by-step instructions for verifying the operation of your PI-SCX system. The intent of this simple procedure is to help you gain basic familiarity with the operation of your system and to show that it is functioning properly. *The procedure does not require an X-ray source.* Once basic familiarity has been established, then operation with other operating configurations, ones with more complex timing modes, can be performed.

Once the PI-SCX system has been installed, operation of the camera is basically straightforward. In most applications you simply establish optimum performance using the **Focus** mode (WinView/32), select full frame, set the target camera temperature, and watch the dark charge decrease as the CCD temperature approaches the set temperature.

Cabling

If the system cables haven't been installed, connect them as instructed in Chapter 4.

Getting Started

1. If the system is water-cooled, double check that the circulator is filled with a 50:50 mixture of ethylene glycol and water and that the hose connections are secure. When satisfied that these requirements are met, do the following.

   - Turn on the circulator. The circulator will power up and begin pumping coolant through the camera. *See the circulator instruction manual for detailed information.*
   - Inspect the coolant hose connections to be sure there are no leaks.
   - Turn on the refrigeration, if this feature is available, and set the coolant temperature (+5° for PI-SCX:4096 with ≤1.5:1 ratio and PI-SCX:4300, 0° for PI-SCX:4096 with >1.5:1 ratio, and +25°C for other PI-SCX models, unless otherwise specified). The compressor will start and cooldown will begin.

2. Verify that the line-voltage setting of the ST-133 is correct for the available power and switch ON the ST-133.

3. Turn on the power at the computer and start the application software (WinView/32, for example).

Setting the Parameters

Note: The following procedure is based on WinView/32: you will need to modify it if you are using a different application. Basic familiarity with the WinView/32 software is assumed. If this is not the case, you may want to review the software manual or have it available while performing this procedure.

Set the software parameters as follows:

Environment dialog (Setup|Environment): Set the DMA Buffer size to 32 Mbytes (96 Mbytes for PI-SCX:4096), ***reboot the computer*** for this memory allocation to be activated, and then restart WinView.

Controller/Camera tab (Setup|Hardware): Controller and Camera parameters should be set automatically to the proper values for your system. However, you can click on the **Load Defaults From Controller** button on this tab to load the default settings.

- **Use PVCAM:** If you are using the USB 2.0 interface, verify that the box is checked.
  Note: This check box is not present on software versions 2.5.19.6 and higher.
- **Controller type:** ST-133
- **Controller version:** 4 or higher
- **Camera type:** The array for your camera will be
  PI-SCX:1300 = EEV 1300x1340F
  PI-SCX:4096 = FCD 4096x4096F
  PI-SCX:4300 = KAF 2084x2084 SCX
- **Shutter type:** None.
- **Readout mode:** Full frame.

Interface tab (Setup|Hardware): Verify that the **High Speed PCI** is selected.

Note: This tab is not available if you are using the USB 2.0 interface.

Cleans and Skips tab (Setup|Hardware): Default

Camera Temperature (Setup|Detector Temperature…):

- -30°C for air-cooled PI-SCX:1300
- -35°C for PI-SCX:1300 with +25° water
- -50°C for PI-SCX:4300 and PI-SCX:4096 (≤ 1.5:1 fiber ratio) with +5° water
- -45°C for PI-SCX:4096 (>1.5:1 fiber ratio) with +0° water

The temperature should drop steadily, reaching the set temperature in about 60 minutes (typical). At that point the green **Temp Lock** LED on the rear of the ST-133 will light and there will be a **locked** indication at the computer monitor, indicating that temperature lock has been established. Some overshoot may occur that may cause temperature lock to be briefly lost and then quickly re-established. If you are reading the actual temperature reported by the application software, there may be a small difference between the set and reported temperature when lock is established. This is normal and does not indicate a system malfunction. Once lock is established, the temperature will be stable to within ±0.05°C.

Note: If you are using the USB 2.0 interface, the Detector Temperature dialog will not display temperature information while you are acquiring data.

Experiment Setup Main tab (Acquisition|Experiment Setup…):

- **Exposure Time:** 100 ms
- **Accumulations & Number of Images:** 1
- **CCD Readout:** Use Full Chip

Experiment Setup Timing tab (Acquisition|Experiment Setup…):

- **Timing Mode:** Free Run
- **Shutter Control:** Normal
- **Safe Mode vs. Fast Mode: Fast Mode**

General tab (Display|Layout…): Select **Horizontal** and **Vertical** Cross Sections.

Acquiring Data

If you are using WinView/32 and the computer monitor for focusing, select **Focus** from the **Acquisition** menu. Successive images will be sent to the monitor as quickly as they are acquired. Since no X-ray source is being used, the acquired images will be of the camera's dark charge. As the CCD temperature decreases, the image will get darker as the dark charge decreases. Signal changes may be more easily seen on the cross-section views.

Figure 17 shows the kind of image data you might see in WinView. The horizontal and vertical cross sections have been turned on via the **General** tab card (**Display|Layout**).

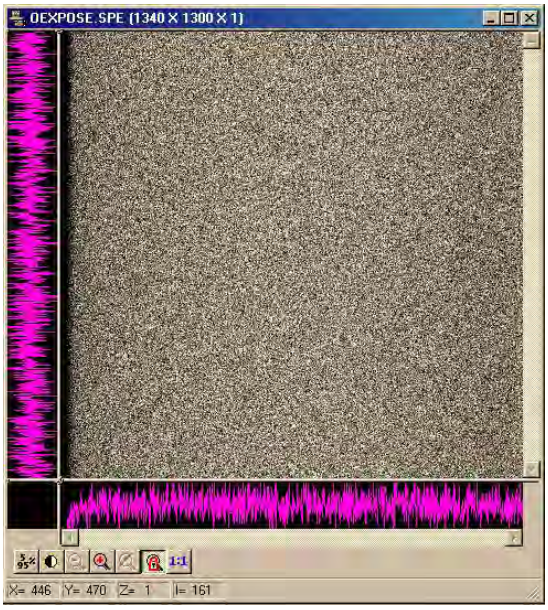


Figure 17. Example of WinView Data Acquired from First Light Procedure

Because the time to acquire and read out an image varies directly with the size of the CCD, the observed frame rate will vary greatly depending on the CCD installed. With a short exposure time, it is not uncommon for the frame readout time to be significantly longer than the exposure time: for a Fairchild 4096x4096 array, a full frame readout at 1 MHz takes approximately 17 seconds.

This completes *First Light*. If the system functioned as described, you can be reasonably sure it has arrived in good working order. In addition, you should have a basic understanding of how the system hardware is used. A recommended procedure for powering down the camera is provided in the next section. Other topics, which could be quite important in certain situations, are discussed in the following chapters. See the appropriate application software manual for information on using the software to control the system.

Power Down Procedure

It is recommended that the camera warm-up be carefully controlled. Proper warm-up will be achieved by proceeding as follows:

1. While running WinView, gradually bring the camera temperature up in 10°C steps from its current lock temperature to ambient temperature. To accomplish this, open the **Detector Temperature** dialog, set the target temperature to 10°C above the current lock temperature, wait until lock is reached, and then raise it again in 10°C steps until ambient temperature is reached.
2. Set the ST-133 Controller's front-panel Power switch to OFF.
3. Set the circulator's refrigeration On/Off switch to OFF.
4. Set the circulator's main power switch to OFF. This completes the warm-up procedure.

Exposure and Signal

Introduction

The following topics address factors that can affect the signal acquired on the CCD array. These factors include array architecture, exposure time, CCD temperature, dark charge, and saturation.

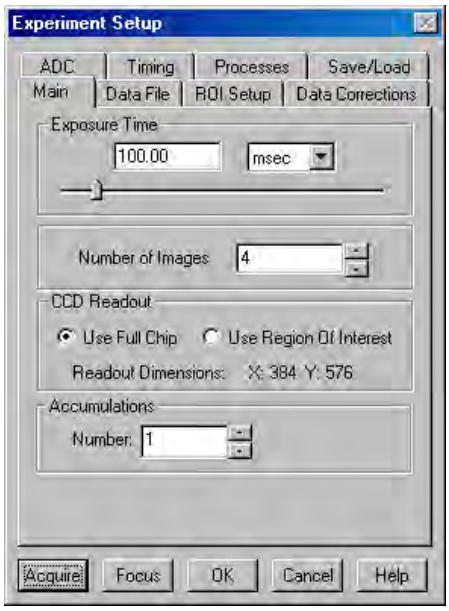
CCD Array Architecture

Charge coupled devices (CCDs) can be roughly thought of as a two-dimensional grid of individual photodiodes (called pixels), each connected to its own charge storage "well." Each pixel senses the intensity of light falling on its collection area, and stores a proportional amount of charge in its associated "well." Once charge accumulates for the specified exposure time (set in the software), the pixels are read out serially.

CCDs are rugged and compact: unintensified, uncoated CCDs can withstand direct exposure to relatively high light levels, magnetic fields and RF radiation. They are easily cooled and can be precisely thermostated to within a few tens of millidegrees.

Because CCD arrays, like film and other media, are always sensitive to light, light must not be allowed to fall on the array during readout (with a few exceptions). Unintensified full-frame CCD cameras like the PI-SCX cameras may require a customer-provided X-ray shutter to prevent light from reaching the CCD during readout.

Exposure Time



Exposure time (set on the **Experiment Setup|Main** tab) is the time between Start Acquisition and Stop Acquisition commands sent by the application software to the camera. In combination with triggers, these commands control when continuous cleaning of the CCD stops and when the accumulated signal will be readout. The continuous cleaning prevents buildup of dark current and unwanted signal prior to the X-ray pulse. At the end of the exposure time, the CCD is readout and cleaning starts again.

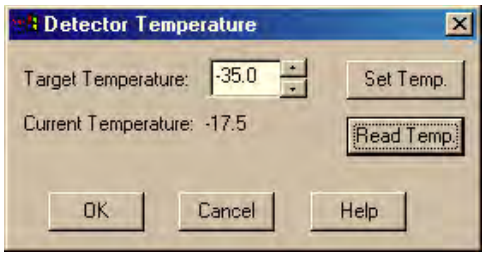
Because PI-SCX cameras do not incorporate an internal shutter, some signal may accumulate on the array while it is being readout. This continuous exposure of the array during readout may result in some smearing. However, exposures that are significantly longer than the readout time can be performed without a shutter, as the amount of smearing will be low.

If smearing or other factors require a shutter, the **NOT SCAN** or the **SHUTTER** signal at the ST-133's $\overline{\text{SCAN}}$ output can be used to control a customer-supplied external X-ray shutter. By using one of the signals to synchronize the shutter operation with exposure, the CCD can be read out in darkness. Alternatively, the X-ray source can be interrupted elsewhere in the system while readout is taking place.

CCD Temperature

Each PI-SCX camera contains a Peltier-effect thermoelectric cooler that cools the CCD. This cooling, which may be assisted by an internal fan or by liquid coolant circulation, reduces the amount of dark charge that is generated on the array. A thermal sensing diode attached to the cooling block of the camera monitors the array temperature and the current temperature is reported back to the operating software. The operating (or target) temperature is settable in software. Ambient temperature, cooling type, and CCD array size all affect the time required to reach and stabilize at the appropriate operating temperature (see Table 8, page 87, for typical cooldown temperatures).

Setting the Temperature



The temperature of the CCD array is set through software. With WinView/32, you enter and set the target temperature after selecting **Detector Temperature** from the **Setup** menu.

Temperature Stabilization

After the system begins cooling, it takes about 60 minutes for the CCD to reach its preset temperature. Because the control loop is designed to achieve temperature lock as quickly as possible, overshoot may occur. If this happens, temperature lock will be briefly indicated and then discontinue during the overshoot. However, the lock indication will be quickly restored

as stable control is re-established. This is normal behavior and should not be a cause for concern. Once temperature lock is established, the temperature is thermostated to within ±0.05°C. The controller is equipped with an LED that indicates temperature lock: this indicator will change to green to indicate lock.

Notes:

1. The time to reach temperature lock is affected by CCD array size and the ambient temperature. Typically, the larger the array or the warmer the ambient temperature, the longer the time to reach lock. If the ambient temperature is above +23°C, temperature lock may not be achievable at the lowest specified temperature for your camera. Temperature regulation does not reach its ultimate stability for at least 30 minutes after lock is established.
2. If you are using the USB 2.0 interface, the Detector Temperature dialog will not display temperature information while you are acquiring data.

Dark Charge

Dark charge (or dark current) is the thermally induced buildup of charge in the CCD over time. Even with the light into the camera completely blocked, the CCD will collect a dark charge pattern, dependent on the exposure time and camera temperature. The longer the exposure time and the warmer the camera, the larger and less uniform this background will appear. Thus, to minimize dark-charge effects, you should set the camera temperature at the lowest CCD temperature within the recommended range for your camera (see Table 8, on page 87).

The statistical noise associated with dark charge is known as dark noise. Dark charge values vary widely from one CCD array to another and are exponentially temperature dependent. At the typical operating temperature of a thermoelectrically-cooled camera, dark charge is reduced by a factor of ~2 for every 6-7 degree reduction in temperature. In the case of cameras such as the PI-SCX cameras, which have MPP type arrays, the average dark charge is extremely small. However, the dark-charge distribution is such that a significant number of pixels may exhibit a much higher dark charge, limiting the maximum practical exposure.

Notes:

1. Do not be concerned about either the DC level of this background or its shape unless it is very high, i.e., > 1000 counts with 16-bit ADC. What you see is not noise. It is a fully subtractable readout pattern. Each CCD has its own dark charge pattern, unique to that particular device. Simply acquire and save a dark charge "background image" under conditions identical to those used to acquire the "actual" image. Subtracting the background image from the actual image will significantly reduce dark-charge effects.
2. Offset and excess noise problems are more likely to occur if the controller and camera weren't calibrated and tested as a system at the factory.

WARNING! If you observe a sudden change in the baseline signal you may have excessive humidity in the camera's vacuum enclosure. Immediately turn off the system. *Refer to Appendix C and contact Princeton Instruments Customer Support for information on how to refresh the vacuum. See page 108 for contact information*.

Saturation

When signal levels in some part of the image are very high, charge generated in one pixel may exceed the "well capacity" of the pixel, spilling over into adjacent pixels in a process called "blooming." In this case a more frequent readout is advisable, with signal averaging to enhance S/N (Signal-to-Noise ratio) accomplished through the software.

For signal levels low enough to be readout-noise limited, longer exposure times, and therefore longer signal accumulation in the CCD, will improve the S/N ratio approximately linearly with the length of exposure time. There is, however, a maximum time limit for on-chip averaging, determined by either the saturation of the CCD pixels by the signal or the loss of dynamic range due to the buildup of dark charge in the pixels

Readout

Introduction

After the exposure time has elapsed, the charge accumulated in the array pixels needs to be read out of the array, converted from electrons to digital format, and transmitted to the application software where it can be displayed and/or stored. Readout begins by moving charge from the CCD image area to the shift register. The charge in the shift register pixels, which typically have twice the capacity of the image pixels, is then shifted into the output node and then to the output amplifier where the electrons are grouped as electrons/count. This result leaves the CCD and goes to the preamplifier where gain is applied.

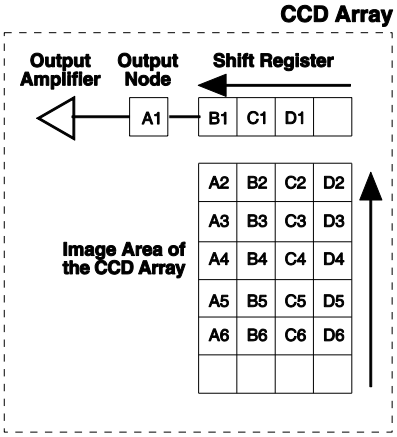


Figure 18. Array Terms for a CCD with a Single Output Amplifier

WinView and WinSpec allow you to specify the type of readout (full frame or binned), the output amplifier (if dual amplifiers are available), and the gain (the number of electrons required to generate an ADU).

Full Frame Readout

In this section, a simple 6 × 4 pixel CCD is used to demonstrate how charge is shifted and digitized. Full frame readout, for full frame CCDs, reads out the entire CCD surface at the same time.

The upper left drawing in Figure 19 represents a CCD after exposure but before the beginning of readout. The capital letters represent different amounts of charge, including both signal and dark charge. This section explains readout at full resolution, where every pixel is digitized separately.

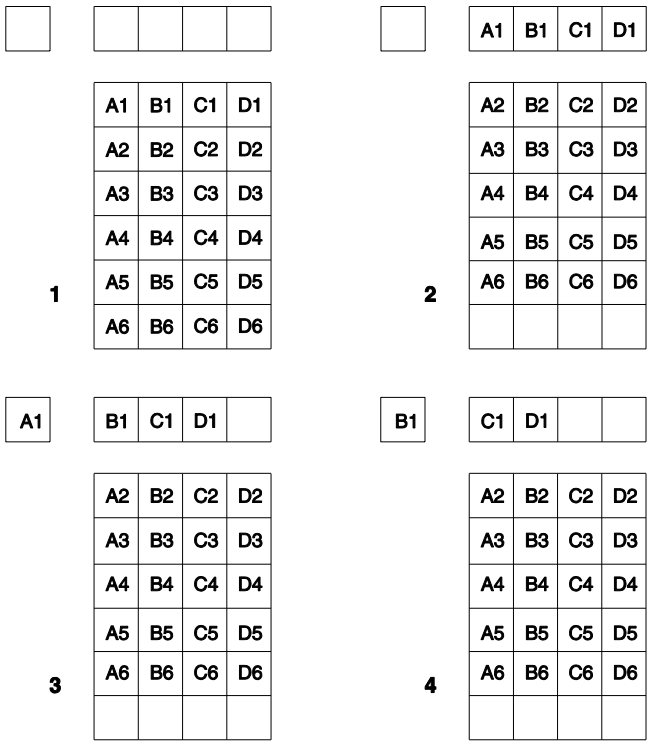


Figure 19. Full Frame at Full Resolution

Readout of the CCD begins with the simultaneous shifting of all pixels one row toward the "shift register," in this case the row at the top. The shift register is a single line of pixels along one edge of the CCD, not sensitive to light and used for readout only. Typically the shift register pixels hold twice as much charge as the pixels in the imaging area of the CCD.

After the first row is moved into the shift register, the charge now in the shift register is shifted toward the output node, located at one end of the shift register. As each value is "emptied" into the output it is digitized. Only after all pixels in the first row are digitized is the second row moved into the shift register. The order of shifting in our example is therefore A1, B1, C1, D1, A2, B2, C2, D2, A3 ....

After charge is shifted out of each pixel the remaining charge is zero, meaning that the array is immediately ready for the next exposure.

A subsection of the CCD can be read out at full resolution, sometimes dramatically increasing the readout rate while retaining the highest resolution in the region of interest (ROI). Note that some overhead time is required to shift out and discard the unwanted pixels.

Binning

Binning is the process of adding the data from adjacent pixels together to form a single pixel (sometimes called a super pixel), and it can be accomplished in either hardware or software. Rectangular groups of pixels of any size may be binned together, subject to some hardware and software limitations.

Hardware Binning

Hardware binning is performed on the CCD array *before* the signal is read out of the output amplifier. For signal levels that are readout noise limited this method improves S/N ratio linearly with the number of pixels grouped together. For signals large enough to render the camera photon shot noise limited, the S/N ratio improvement is roughly proportional to the square root of the number of pixels binned.

Binning also reduces readout time and the burden on computer memory, but at the expense of resolution. Since shift register pixels typically hold only twice as much charge

as image pixels, the binning of large sections may result in saturation and "blooming", or spilling of charge back into the image area.

Figure 20 shows an example of 2 × 2 binning. Each pixel of the image displayed by the software represents 4 pixels of the CCD array. Rectangular bins of any size are possible.

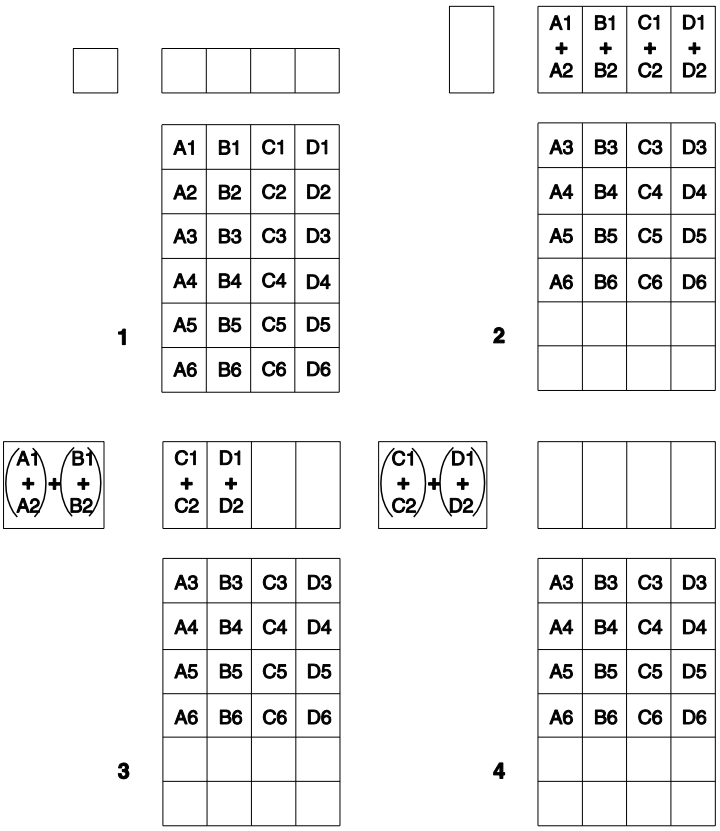


Figure 20. 2 × 2 Binning

Software Binning

One limitation of hardware binning is that the shift register pixels and the output node are typically only 2-3 times the size of imaging pixels. Consequently, if the total charge binned together exceeds the capacity of the shift register or output node, the data will be lost.

This restriction strongly limits the number of pixels that may be binned in cases where there is a small signal superimposed on a large background, such as signals with a large fluorescence. Ideally, one would like to bin many pixels to increase the S/N ratio of the weak peaks but this cannot be done because the fluorescence would quickly saturate the CCD.

The solution is to perform the binning in software. Limited hardware binning may be used when reading out the CCD. Additional binning is accomplished in software, producing a result that represents many more photons than was possible using hardware binning.

Software averaging can improve the S/N ratio by as much as the square root of the number of scans. Unfortunately, with a high number of scans, i.e., above 100, camera 1/f noise may reduce the actual S/N ratio to slightly below this theoretical value. Also, if the light source used is photon-flicker (1/f noise) limited rather than photon shot-noise limited, this theoretical signal improvement cannot be fully realized. Again, background subtraction from the raw data is necessary.

This technique is also useful in high light level experiments, where the camera is again photon shot-noise limited. Summing multiple pixels in software corresponds to collecting more photons, and results in a better S/N ratio in the measurement.

Output Amplifier Selection

The output amplifier amplifies the collected charge from the output node and outputs it as electrons/count. Although Figure 18 shows an array with a single output node and amplifier, some PI-SCX systems are available with dual output nodes and amplifiers (one set at each end of the shift register). If your system has dual output amplifiers, you can choose the output amplifier to be used (High Capacity or Low Noise) via WinView/32 or WinSpec/32 on the **Acquisition|Experiment Setup…|Main** tab:

- **High Capacity amplifier:** Provides a spectrometric well capacity that is approximately 3 times the well capacity for the Low Noise amplifier selection. High Capacity is suitable when you have intense light signals or signals with high dynamic range.
- **Low Noise amplifier:** Provides the highest sensitivity performance and is suitable when you have weak signals.

Note: The choice of output amplifier and analog gain setting should be considered together for the best signal capture.

Analog Gain Control

Note: A gain control switch is located on the rear of the PI-SCX:1300 camera but has been deactivated. However, analog gain is changeable via the WinView/WinSpec software (on the **Acquisition| Experiment Setup…|ADC** tab card). If your camera is not designed for analog gain selection, these settings will not be accessible in the software.

Analog gain control (a function of the preamplifier) is used to change the relationship between the number of electrons acquired on the CCD and the Analog-to-Digital Units (ADUs or counts) generated. In WinView/32 and WinSpec/32, the analog gain choices vary depending on the CCD array and the number of output amplifiers:

- **Single Amplifier:** Typically, three settings are available: Low 2x, Medium 1x, and High 1/2x.
- **Dual Amplifier:** Typically, three settings are available: Low 2x, Medium 1x, and High 1/2x (Low-noise mode) or Low 4x, Medium 2x, and High 1x (High-capacity mode).

The analog gain of the detector should generally be set so that the overall noise is ~1 count RMS. In most instances this will occur with the switch set to **Medium**. If the array is a 1340 × 1300 *configured with the low-noise output*, **Low** will probably be a more suitable Analog Gain setting. In situations where the A/D range exceeds that of the array, it will generally be better to set the Analog Gain to **High** so that the signal can be spread over as much of the A/D range as possible. This is a particularly important consideration in absorbance measurements. Users who consistently measure low-level signals may wish to select **High**, which reduces some sources of noise. Users who measure high-level signals may wish to select **Low** to allow digitization of larger signals. Customized values of gain can be provided. Contact Princeton Instruments for additional information.

Example: The following descriptions assume that the actual incoming light level is identical in all three instances. ***The numbers used illustrate the effect of changing an analog gain setting and do not reflect actual performance: gain at the Low, Medium, and High settings depends on the CCD installed and the amplifier selected.***

Low requires four electrons to generate one ADU. Strong signals can be acquired without flooding the CCD array. If the gain is set to **Low** and the images or spectra appear weak, you may want to change the gain setting to **Medium** or **High**.

Medium requires two electrons to generate one ADU. If the gain is set to **Medium** and the images or spectra do not appear to take up the full dynamic range of the CCD array, you may want to change the gain setting to **High**. If the CCD array appears to be flooded with light, you may want to change the setting to **Low**.

High requires one electron to generate one ADU and some noise sources are reduced. Because fewer electrons are needed to generate an ADU, weaker signals can be more readily detected. Lower noise further enhances the ability to acquire weak signals. If the CCD array appears to be flooded with light, you may want to change the setting to **Medium** or **Low**.

Note: The baseline level may require adjustment if you change the analog gain. See the ***"ADC Offset"*** section on page 54 for more information.

Digitization

Introduction

After gain has been applied to the signal, the Analog-to-Digital Converter (ADC) converts that analog information (continuous amplitudes) into a digital data (quantified, discrete steps) that can be read, displayed, and stored by the application software. The number of bits per pixel is based on both the hardware and the settings programmed into the camera through the software (see ***"Readout",*** page 49).

Factors associated with digitization include the digitization rate and baseline signal. Depending on the camera model, you may be able change the speed at which digitization occurs and/or offset the baseline. These factors are discussed in the following paragraphs.

Digitization Rate

Depending on the PI-SCX system, the camera may contain single (1 MHz) or dual digitizers (100 kHz/1 MHz or 50kHz/1 MHz). When a camera has a single digitizer, the data can only be digitized at that speed. However, for cameras with dual digitization, you have a choice of how quickly the data will be digitized (with optimum signal-to-noise ratios at both readout speeds). Because the readout noise of CCD arrays increases with the readout rate, it is sometimes necessary to trade off readout speed for high dynamic range. The 1 MHz conversion speed is used for the fastest possible data collection and the 100 kHz or 50 kHz conversion speed is used where noise performance is the paramount concern. Switching between the conversion speeds is completely under software control for total experiment automation.

Note: If the camera has dual digitization, the ADC rate can be changed on the **Experiment Setup|ADC** tab.

ADC Offset

ADC offset (also known as baseline offset) provides another way of dealing with dark charge (see ***"Dark Charge"***, page 48). By offsetting the baseline signal, much of the background is ignored during conversion.

Offsetting the baseline is accomplished by adding a voltage to the signal to bring the A/D output to a non-zero value, typically 50-100 counts. This offset value ensures that all the true variation in the signal can really be seen and not lost below the A/D "0" value. Since the offset is added to the signal, these counts only minimally reduce the range of the signal from 65535 (16-bit A/D) to a value in the range of 50-100 counts lower.

Notes:

1. Do not be concerned about either the DC level of the baseline signal or its shape unless it is very high (i.e., > 1000 counts with 16-bit ADC).
2. The ADC Offset can be adjusted by using the F and S Zero pots located on the rear panel of the controller. If these pots are not present, the ADC Offset may be software-adjustable on the **Experiment Setup|ADC** tab.
3. Do not adjust the offset values to zero or some low-level data will be missed.

WARNING! If you observe a sudden change in the baseline signal you may have excessive humidity in the camera's vacuum enclosure. ***TURN OFF THE SYSTEM IMMEDIATELY.*** *Contact Princeton Instruments Customer Support for information on how to refresh the vacuum. See page 108 for contact information*.

Chapter 6

Advanced Topics

Introduction

Previous chapters have discussed setting up the hardware and the software for basic operation. This chapter discusses topics associated with experiment synchronization (set up on the **Experiment Setup|Timing** tab in WinView and WinSpec).With the exception of Edge Trigger, the topics are addressed in order of their appearance on the Timing tab (see Figure 21).

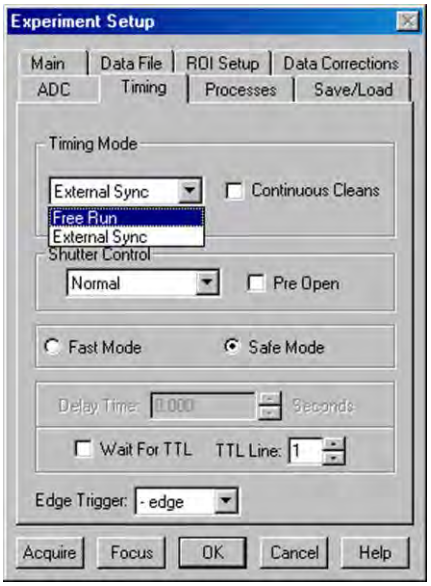


Figure 21. Timing tab

"Timing Modes", the first topic, discusses standard Timing Modes, Shutter Control, and Edge Trigger. Also included under this topic is a discussion of the **EXT SYNC** connector, the input connector for a trigger pulse.

"Fast Mode and Safe Mode", the second topic, discusses the Fast and the Safe speed modes. Fast is used for real-time data acquisition and Safe is used when coordinating acquisition with external devices or when the computer speed is not fast enough to keep pace with the acquisition rate.

"TTL Control", the final topic, discusses the TTL IN/Out connector on the rear of the ST-133 and how commands can be sent via TTL levels to and from the ST-133.

Timing Modes

The chart to the right lists the timing mode combinations (selected on the **Experiment Setup|Timing** tab). Use this chart in combination with the detailed descriptions in this chapter to determine the optimal timing configuration.

The basic timing modes are Free Run, External Sync, and External Sync with Continuous Cleans. These modes are combined with the Shutter options to provide the widest variety of timing modes for precision experiment synchronization.

Mode	Shutter
Free Run	Normal
External Sync	Normal
External Sync	PreOpen
External Sync with Continuous Cleans	Normal
External Sync with Continuous Cleans	PreOpen

Table 3. Camera Timing Modes

The shutter options available include Normal, PreOpen, Disable Opened or Disable Closed. Disable simply means that the shutter will not operate during the experiment. Disable closed is useful for making dark charge measurements or when no shutter is present. PreOpen, available in the External Sync and External Sync with Continuous

Cleans modes, opens the shutter as soon as the ST-133 is ready to receive an External Sync pulse. This is required if the time between the External Sync pulse and the event is less than a few milliseconds, the time it takes the shutter to open.

The shutter timing is shown in the timing diagrams that follow. Except for Free Run, where the modes of shutter operation are identical, both Normal and PreOpen lines are shown in the timing diagrams and flowchart.

The timing diagrams are labeled indicating the exposure time (t_{exp}), shutter compensation time (t_c), and readout time (t_R). Note that if there is no shutter selected in the software, the shutter compensation time (the time required to close a mechanical shutter) will be approximately 0 ms.

Free Run

In the Free Run mode the controller does not synchronize with the experiment in any way. The shutter opens as soon as the previous readout is complete, and remains open for the exposure time, t_{exp}. Any External Sync signals are ignored. This mode is useful for experiments with a constant light source. Other experiments that can utilize this mode are high repetition studies, where the number of shots that occur during a single shutter cycle is so large that it appears to be continuous illumination.

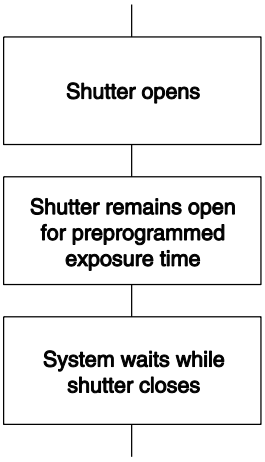


Figure 22. Free Run Timing Chart, part of the chart in Figure 28

Other experimental equipment can be synchronized to the ST-133 controller by using the output signal (software-selectable **SHUTTER** or **NOT SCAN** on the **Hardware Setup|Controller Camera** tab) from the SCAN connector. Shutter operation and the NOT SCAN output signal are shown in Figure 23.

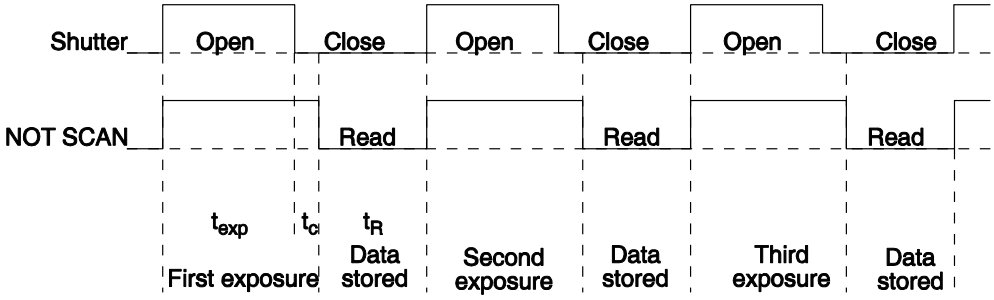


Figure 23. Free Run Timing Diagram

External Sync

In this mode all exposures are synchronized to an external source via signal input to the Ext Sync BNC on the back of the ST-133. To ensure synchronization, the trigger edge (negative- or positive-going) of the Ext Sync signal must be identified in the application software (in WinView and WinSpec, this is done on the **Experiment Setup|Timing** tab). As shown in the flowchart, Figure 24, External Sync mode can be used in combination with Normal or PreOpen Shutter operation. In Normal Shutter mode, the controller waits for an External Sync pulse and then opens the shutter for the

programmed exposure period. As soon as the exposure is complete, the shutter closes and the CCD array is read out.

Because the external shutter requires a finite amount of time to open completely (shutter open time may be 5-28 ms depending on the shutter), the External Sync pulse trigger edge provided by the experiment should precede the actual signal by at least that much time. If not, the shutter will not be open for the duration of the entire signal, or the signal may be missed completely.

Also, since the amount of time from initialization of the experiment to the first External Sync pulse trigger edge is not fixed, an accurate background subtraction may not be possible for the first readout. In multiple-shot experiments this is easily overcome by simply discarding the first frame.

In the PreOpen Shutter mode, on the other hand, shutter operation is only partially synchronized to the experiment. As soon as the controller is ready to collect data, the shutter opens. Upon arrival of the first External Sync pulse trigger edge at the ST-133, the shutter remains open for the specified exposure period, closes, and the CCD is read out. As soon as readout is complete, the shutter reopens and waits for the next frame.

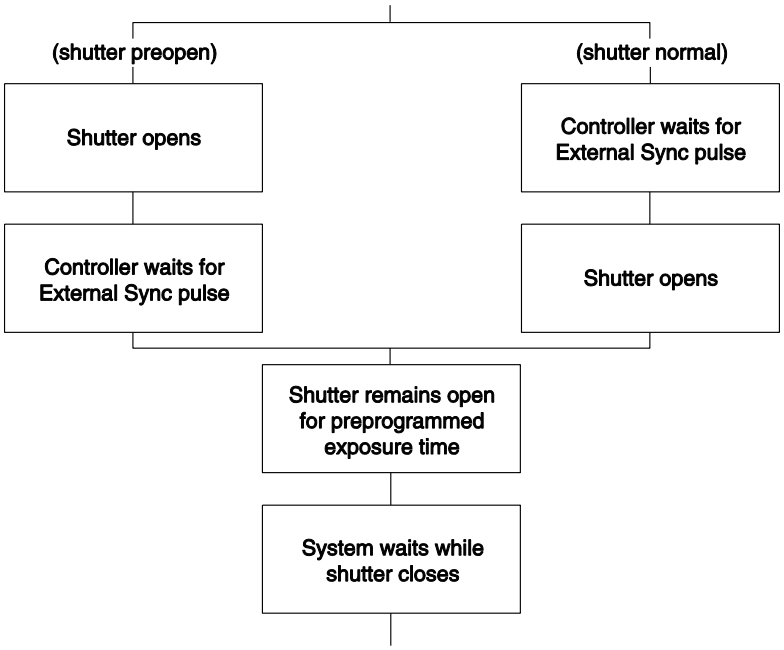

(shutter preopen)
(shutter normal)
Shutter opens
Controller waits for External Sync pulse
Controller waits for External Sync pulse
Shutter opens
Shutter remains open for preprogrammed exposure time
System waits while shutter closes

Figure 24. Chart Showing Two External Sync Timing Options

The PreOpen mode is useful in cases where an External Sync pulse trigger edge cannot be provided 5-28 ms (shutter open time) before the actual signal occurs. Its main drawback is that the CCD is exposed to any ambient light while the shutter is open between frames. If this ambient light is constant and the triggers occur at regular intervals, this background can also be subtracted, providing that it does not saturate the CCD. As with the Normal Shutter mode, accurate background subtraction may not be possible for the first frame.

Also note that, in addition to signal from ambient light, dark charge accumulates during the "wait" time (t_w). Any variation in the external sync frequency also affects the amount of dark charge, even if light is not falling on the CCD during this time.

Note: If EXT SYNC is still active (in Figure 25, this means that if it is still LOW) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

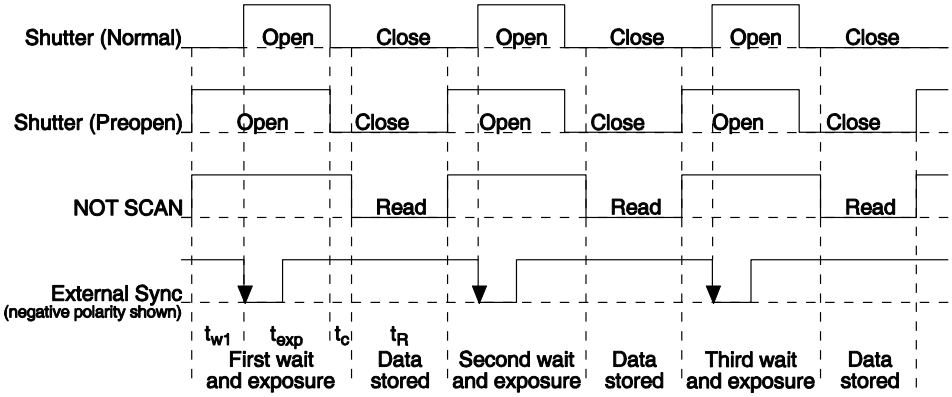


Figure 25. Timing Diagram for the External Sync Mode (- edge trigger)

External Sync with Continuous Cleans

Another timing mode available with the ST-133 controller is called Continuous Cleans. In addition to the standard "cleaning" of the array, which occurs after the controller is enabled, Continuous Cleans will remove any charge from the array until the moment the External Sync pulse trigger edge is received.

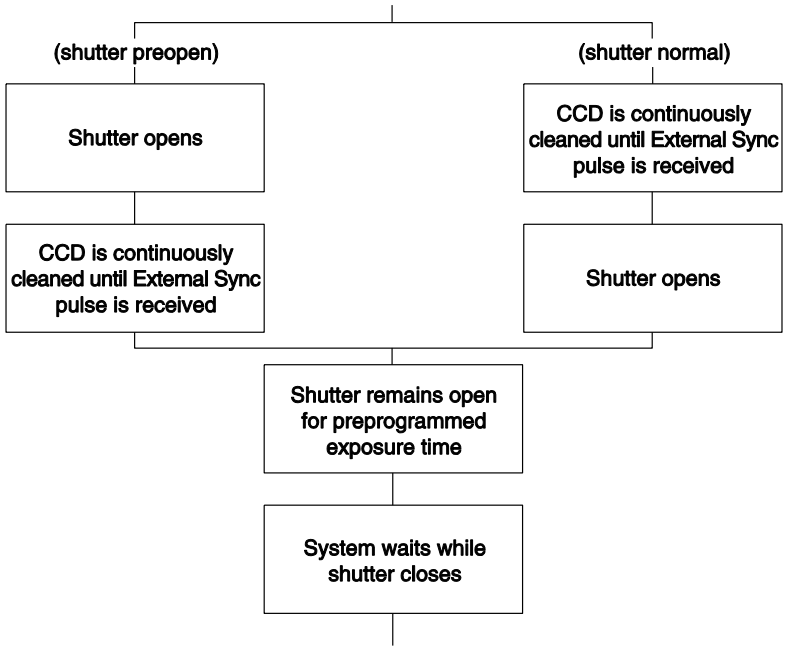

(shutter preopen)
(shutter normal)
Shutter opens
CCD is continuously cleaned until External Sync pulse is received
CCD is continuously cleaned until External Sync pulse is received
Shutter opens
Shutter remains open for preprogrammed exposure time
System waits while shutter closes

Figure 26. Continuous Cleans Operation Flowchart

Once the External Sync pulse trigger edge is received, cleaning of the array stops as soon as the current row is shifted, and frame collection begins: a delay time of up to one row shift can be expected. With Normal Shutter operation the shutter is opened for the set exposure time. With PreOpen Shutter operation the shutter is open during the continuous cleaning, and once the External Sync pulse trigger edge is received, the shutter remains open for the set exposure time, then closes. If the vertical rows are shifted midway when the External Sync pulse trigger edge arrives, the pulse is saved until the row shifting is

completed, to prevent the CCD from getting "out of step." As expected, the response latency is on the order of one vertical shift time, from 1-30 µs depending on the array. This latency does not prevent the incoming signal from being detected, since photo-generated electrons are still collected over the entire active area. However, if the signal arrival is coincident with the vertical shifting, image smearing of up to one pixel is possible. The amount of smearing is a function of the signal duration compared to the single vertical shift time.

Note: If EXT SYNC is still active (in Figure 27, this means that if it is still LOW) at the end of the readout, the hardware may interpret this as a second sync pulse, and so on.

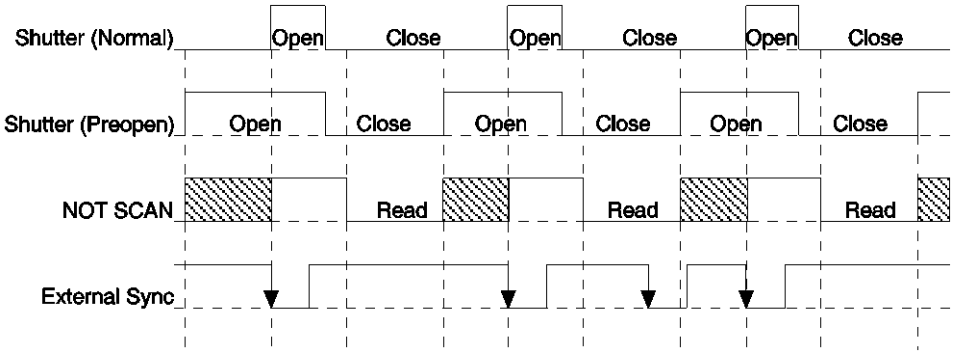


Figure 27. Continuous Cleans Timing Diagram (-edge trigger)

Fast Mode and Safe Mode

The **Experiment Setup|Timing** tab allows you to choose **Fast Mode** or **Safe Mode**. Figure 28 is a flowchart comparing the two modes. In Fast Mode operation, the ST-133 runs according to the timing of the experiment, with no interruptions from the computer. In Safe Mode operation, the computer processes each frame as it is received. The ST-133 cannot collect the next frame until the previous frame has been completely processed.

Fast Mode operation is primarily for collecting "real-time" sequences of experimental data, where timing is critical and events cannot be missed. Once the ST-133 is sent the Start Acquisition command by the computer, all frames are collected without further intervention from the computer. The advantage of this timing mode is that timing is controlled completely through hardware. A drawback to this mode is that the computer will only display frames when it is not performing other tasks. Image display has a lower priority, so the image on the screen may lag several images behind. *A video monitor connected to the VIDEO output will always display the current image.* A second drawback is that a data overrun may occur if the number of images collected exceeds the amount of allocated RAM or if the computer cannot keep up with the data rate.

Safe Mode operation is primarily useful for experiment setup, including alignment and focusing, when it is necessary to have the most current image displayed on the screen. It is also useful when data collection must be coordinated through software with external devices such as external shutters and filter wheels. As seen in Figure 28, in Safe Mode operation, the computer controls when each frame is taken. After each frame is received, the camera sends the Stop Acquisition command to the camera, instructing it to stop acquisition. Once that frame is completely processed and displayed, another Start Acquisition command is sent from the computer to the camera, allowing it to take the next frame. Display is therefore, at most, only one frame behind the actual data collection.

One disadvantage of the Safe Mode is that events may be missed during the experiment, since the ST-133 is disabled for a short time after each frame.

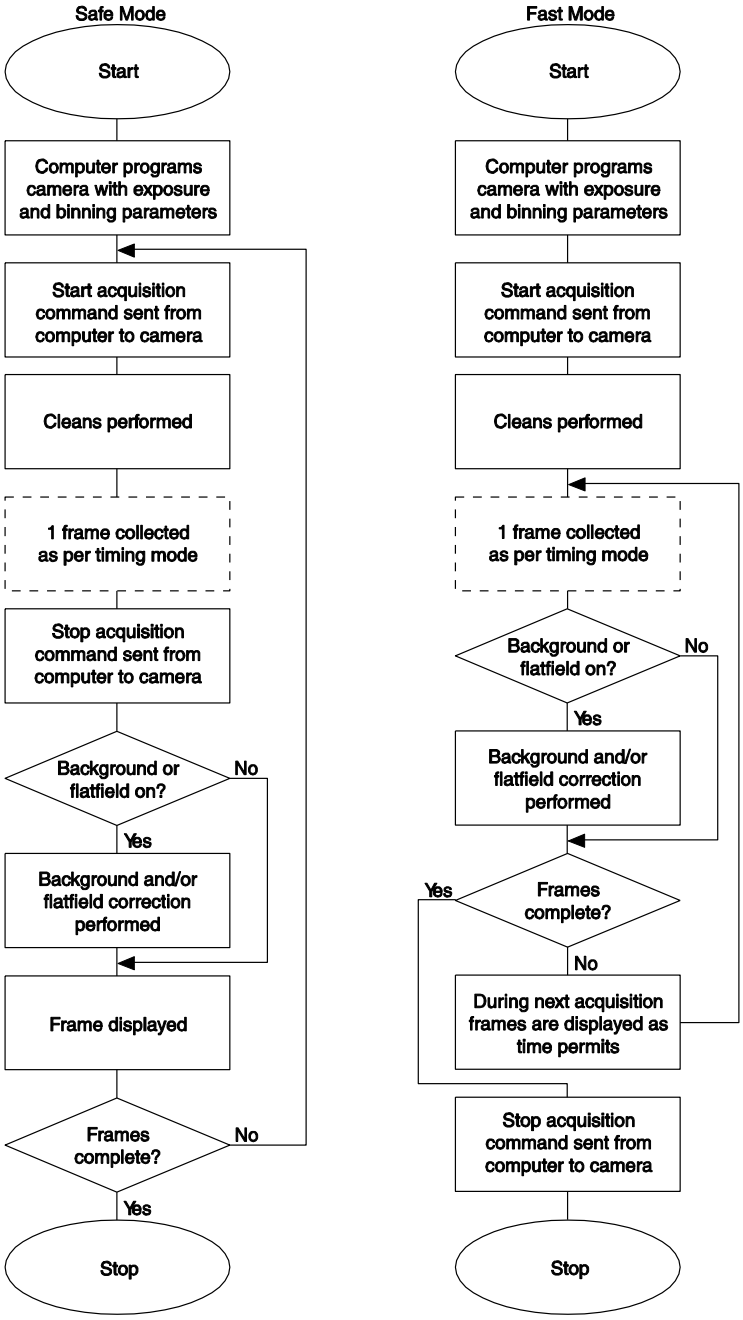


Figure 28. Chart of Safe Mode and Fast Mode Operation

TTL Control

Fully supported by WinView/WinSpec Version 2.5 when the communication protocol is TAXI (PCI), this feature is not supported when the protocol is USB 2.0.

Introduction

Princeton Instruments' WinView and WinSpec software packages incorporates WinX32 Automation, a programming language that can be used to automate performing a variety of data acquisition and data processing functions, including use of the TTL In/Out functions. WinX32 Automation can be implemented in programs written in Visual Basic or Visual C++. See the WinX32 documentation for more detailed information.

The TTL lines are made available through the TTL In/Out connector on the rear of the ST-133 Controller. This connector provides 8 TTL lines in, 8 TTL lines out and an input control line. Figure 29 illustrates the connector and Table 5 lists the signal/pin assignments.

TTL In

The user controls the 8 TTL Input lines, setting them high (+5 V; TTL 1) or low (0 V; TTL 0). When the lines are read, the combination of highs and lows read defines a decimal number which the computer can use to make a decision and initiate actions as specified in the user's program. If a TTL IN line is low, its numeric value is 0. If a TTL IN line is high, its numeric value is as follows.

TTL IN	Value	TTL IN	Value
1	1	5	16
2	2	6	32
3	4	7	64
4	8	8	128

This coding allows any decimal value from 0 to 255 to be defined. Thus, as many as 256 different sets of conditions can be specified, at the user's discretion, using the TTL IN lines. *Any unused lines will default to TTL high (+5 V).* For example, to define the number three, the user would simply set the lines TTL IN 1 and TTL IN 2 both high (+5 V). It would be necessary to apply TTL low to the remaining six lines because they would otherwise default to TTL high as well.

TTL IN	Value	TTL IN	Value
1	High (1)	5	Low (0)
2	High (2)	6	Low (0)
3	Low (0)	7	Low (0)
4	Low (0)	8	Low (0)

Table 4 illustrates this coding for decimal values 0 through 7. Obviously this table could easily be extended to show the coding for values all the way to 255.

Decimal Equiv.	TTL IN/OUT 8 1= dec 128	TTL IN/OUT 7 1=dec 64	TTL IN/OUT 6 1=dec 32	TTL IN/OUT 5 1=dec 16	TTL IN/OUT 4 1=dec 8	TTL IN/OUT 3 1=dec 4	TTL IN/OUT 2 1=dec 2	TTL IN/OUT 1 1=dec 1
0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	1
2	0	0	0	0	0	0	1	0
3	0	0	0	0	0	0	1	1
4	0	0	0	0	0	1	0	0
5	0	0	0	0	0	1	0	1
6	0	0	0	0	0	1	1	0
7	0	0	0	0	0	1	1	1

Table 4. Bit Values with Decimal Equivalents:
1 = High,
0 = Low

Buffered vs. Latched Inputs

In controlling the TTL IN lines, users also have the choice of two input-line states, *buffered* or *latched*. In the buffered state, the line levels must remain at the intended levels until they are read. With reference to the preceding example, the high level at TTL IN 1 and TTL IN 2 would have to be maintained until the lines are read. In the latched state, the applied levels continue to be available until read, even if they should change at the TTL In/Out connector.

This control is accomplished using the EN/CLK TTL input (pin 6). If EN/CLK is open or high, *buffered* operation is established and the levels reported to the macro will be those in effect when the READ is made. With reference to our example, if pin 6 were left unconnected or a TTL high applied, TTL IN 1 and TTL IN 2 would have to be held high until read. If, on the other hand, EN/CLK were made to go low while TTL IN 1 and TTL IN 2 were high, those values would be *latched* for *as long as EN/CLK remained low*. The levels actually present at TTL IN 1 and TTL IN 2 could then change without changing the value that would be read by software.

TTL Out

The state of the TTL OUT lines is set from WinView/32 (or WinSpec/32). Typically, a program (for example, a macro) monitoring the experiment sets one or more of the TTL Outputs. Apparatus external to the PI-SCX system interrogates the lines and, on detecting the specified logic levels, takes the action appropriate to the detected condition. The coding is the same as for the input lines. There are eight output lines, each of which can be set low (0) or high (1). The combination of states defines a decimal number as previously described for the TTL IN lines.

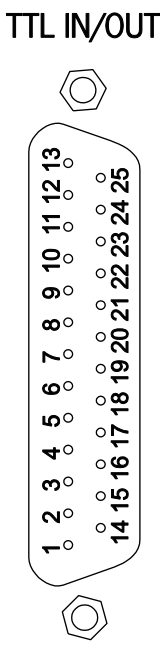


Figure 29. TTL In/Out Connector

Pin #	Assignment	Pin #	Assignment
1	IN 1	14	IN 2
2	IN 3	15	IN 4
3	IN 5	16	IN 6
4	IN 7	17	IN 8
5	GND	18	GND
6	EN/CLK	19	Reserved
7	(future use)	20	GND
8	GND	21	OUT 2
9	OUT 1	22	OUT 4
10	OUT 3	23	OUT 6
11	OUT 5	24	OUT 8
12	OUT 7	25	GND
13	Reserved		

Table 5. TTL In/Out Connector Pinout

TTL Diagnostics Screen

Note that WinView/32 and WinSpec/32 provide a TTL Diagnostics screen (located in WinView/32 under **Hardware Setup|Diagnostics**) that can be used to test and analyze the TTL In/Out lines.

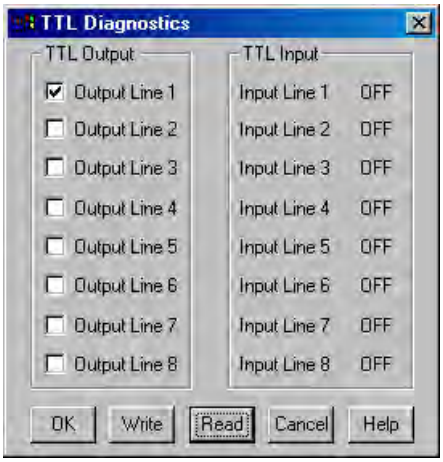


Figure 30. TTL Diagnostics dialog

Hardware Interface

A cable will be needed to connect the TTL In/Out connector to the experiment. The design will vary widely according to each user's needs, but a standard 25-pin female type D-subminiature connector will be needed to mate with the TTL In/Out connector on the back of the ST-133. The hardware at the other end of the cable will depend entirely on the user's requirements. If the individual connections are made using coaxial cable for maximum noise immunity (recommended), the center conductor of the coax should connect to the proper signal pin and the cable shield should connect to the nearest available ground (grounds are conveniently provided at pins 5, 8, 18 and 20). Connector hardware and cables of many different types are widely available and can often be obtained locally, such as at a nearby Radio Shack® store. A list of possibly useful items follows. Note that, although the items listed may be appropriate in many situations, they might not meet your specific needs.

- 25-pin female type D-subminiature solder type connector (Radio Shack® part number 276-1548B).
- RG/58U coaxial cable.

- Shielded Metalized hood (Radio Shack part no 276-1536A).
- BNC connector(s) type UG-88 Male BNC connector (Radio Shack part no 278-103).

Example

Suppose you needed to build a cable to monitor the line TTL OUT 1. One approach would be to build a cable assembly as described in the following paragraphs. This procedure could easily be adapted to other situations.

1. Begin with a 25-pin female type D-subminiature solder type connector (Radio Shack part no 276-1548B). This connector has 25 solder points open on the back.
2. Referring to Table 5, note that pin 8 = GND and pin 9 = TTL OUT 1.
3. Using coaxial cable type RG/58U (6 feet length), strip out the end and solder the outer sheath to pin 8 (GND) and the inner line to pin 9 (TTL OUT 1). Then apply shielding to the lines to insulate them.
4. Mount the connector in a Shielded Metalized hood (Radio Shack part no 276-1536A).
5. Build up the cable (you can use electrical tape) to where the strain relief clamp holds.
6. Connect a BNC connector (UG-88 Male BNC connector) to the free end of the cable following the instructions supplied by Radio Shack on the box (Radio Shack part no 278-103).
7. To use this cable, connect the DB-25 to the TTL In/Out connector on the back of the ST-133.
8. To check the cable, start WinView/32 and open the TTL Diagnostics screen (located in WinView under **Hardware Setup|Diagnostics**). Click the **Write** radio button. Then click the **Output Line 1** box. Next click the **OK** button to actually set TTL OUT 1 high. Once you set the voltage, it stays until you send a new command.
9. Measure the voltage at the BNC connector with a standard voltmeter (red on the central pin, black on the surrounding shielding). Before clicking **OK** at the TTL Diagnostics screen you should read 0 V. After clicking **OK** you should read +5 V.

Note that adding a second length of coaxial cable and another BNC connector would be straightforward. However, as you increase the number of lines to be monitored, it becomes more convenient to consider using a multiple conductor shielded cable rather than individual coaxial cables.

Chapter 7

Troubleshooting

WARNING! Do not attach or remove any cables while the PI-SCX system is powered on.

Introduction

The PI-SCX system is designed to be highly reliable. Nevertheless, problems could develop. In most instances, the best recourse will be to contact the factory for guidance. Most often the system will be most reliably and quickly restored to service by identifying the faulty component and returning it to the factory for service. The information in this chapter is provided as an aid for gathering information that will assist in identifying the source of the problem. The most likely problem with the camera would be gradual deterioration of the vacuum to where temperature lock can no longer be achieved.

WARNING! Do ***NOT*** attempt any disassembly of the camera. The camera sections have Indium vacuum seals where they join. Attempting to disassemble the camera would damage these seals. Once the integrity of a seal is compromised, there would be no alternative but to return the camera to the factory for repair. Such a repair would ***not*** be covered by the equipment Warranty.

The following issues have corresponding troubleshooting sections in this chapter.

Baseline Signal Suddenly Changes	Page 66
Camera Stops Working	Page 66
Camera1 (or similar name) in Camera Name field	Page 66
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Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)	Page 73
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No CCD Named in the Hardware Wizard:CCD dialog (Versions 2.5.19.0 and earlier)	Page 79
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Removing/Installing a Plug-In Module	Page 80
Securing the Detector-Controller Cable Slide Latch	Page 82
Serial violations have occurred. Check interface cable.	Page 83

Baseline Signal Suddenly Changes

If you observe a sudden change in the baseline signal, you may have excessive humidity in the vacuum enclosure of the camera. Turn off the controller and have the camera repumped before resuming normal operation. *Contact the factory Customer Support Dept. for information on how to refresh the vacuum. See page 108 for contact information.*

Camera Stops Working

Problems with the host computer system or software may have side effects that appear to be hardware problems. If you are sure the problem is in the PI-SCX system hardware, begin with these simple checks:

- Turn off all AC power.
- Verify that all cables are securely fastened and that all locking screws are in place.
- Check for a burned-out fuse in the Controller power input module. For information about changing a fuse, see ***"Changing the ST-133's Line Voltage and Fuses"*** on page 67.
- Correct any apparent problems and turn the system on.

If the system still does not respond, contact *Customer Support*.

Camera1 (or similar name) in Camera Name field

Figure 31. Camera1 in Camera Name Field

When a PVCAM-based camera is detected/selected during the Camera Detection wizard (formerly the Hardware Setup wizard), a default name such as Camera1 will be shown in the Detected Hardware table and will be entered in the **Camera Name** field on the **Setup|Hardware|Controller/CCD** tab. Because this name is not particularly descriptive, you may want to change it. Such a change is made by editing the PVCAM.INI file that is generated by Camera Detection wizard (or by the RSConfig.exe if you have a software version 2.5.19.0 or earlier).

To change the default Camera Name:

1. Using **Notepad** or a similar text editor, open **PVCAM.INI**, which is located in the Windows directory (C:\Windows, for example). You should see entries like the ones below.

   [Camera_1]
   Type=1
   Name=Camera1
   Driver=apausb.sys
   Port=0
   ID=523459

2. Change the "Name=" entry to something more meaningful for you (for example, ST133USB - to indicate that this is a PVCAM-based system using an ST-133 with a USB 2.0 interface) and save the edited file.

   [Camera_1]
   Type=1
   Name=ST133USB
   Driver=apausb.sys
   Port=0
   ID=523459

3. The new camera name will now appear in the **Camera Name** field.

Changing the ST-133's Line Voltage and Fuses

The appropriate voltage setting for your country is set at the factory and can be seen on the power input module. If your voltage source changes, you will need to change the voltage setting and you may need to change the fuse configuration.

WARNING! Use proper fuse values and types for the controller and camera to be properly protected.

To Change Voltage and Fuse Configuration:

WARNING! Turn the Controller OFF and unplug the line cord before opening the power input module.

1. As shown in Figure 32, place the flat side of a flat bladed screwdriver parallel to the back of the Controller and behind the small tab at the top of the power module, and twist the screwdriver slowly but firmly to pop the module open.
2. To change the voltage setting, roll the selector drum until the setting that is closest to the actual line voltage is facing outwards.

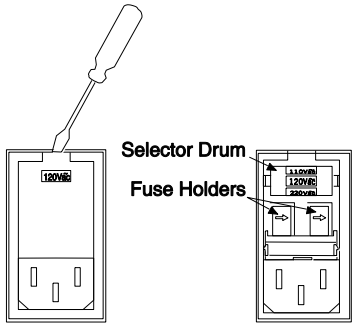


Figure 32. Power Input Module

3. Confirm the fuse ratings by removing the two white fuse holders. To do so, simply insert the flat blade of the screwdriver behind the front tab of each fuse holder and gently pry the assembly out.

Figure 33. Fuse Holder

4. Refer to the Fuse/Voltage label (above or below the Power Module) to see which fuses are required by the selected voltage. If Controller power switch is on the back of the ST-133, the Fuse/Voltage label is located below the Power Module.
5. After inspecting and if necessary, changing the fuses to those required by the selected voltage, reinstall the holders with the arrow facing to the right.
6. Close the power module and verify that the correct voltage setting is displayed.
7. Verify that the Controller power switch is in the OFF position and then plug the power cord back into the power module.

Controller Is Not Responding

If this message pops up when you click on **OK** after selecting the "Interface Type" during **Hardware Setup** (under the WinView/32 **Setup** menu), the system has not been able to communicate with the Controller. Check to see if Controller has been turned ON and if the interface card, its driver, and the interface cable have been installed.

- If the Controller is ON, the problem may be with the interface card, its driver, interrupt or address conflicts, or the cable connections.
- If the interface card is not installed, close the application program and turn the Controller OFF. Follow the interface card installation instructions in provided with your interface card and cable the card to the SERIAL COM port on the rear of the Controller. Then do a "Custom" installation of WinView/32 with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

  Note: WinView/32 (versions 2.6.0 and higher) does not support the ISA interface.

- If the interface card is installed in the computer and is cabled to the SERIAL COM port on the rear of the Controller, close the application program and turn the Controller OFF. Check the cable connections and tighten the locking screws if the connections are loose.
- If the interface card was installed after WinView/32 has been installed, close that application and do a "Custom" installation of it with the appropriate interface component selected: "PCI Interface" or "ISA Interface", depending on the interface card type. Be sure to deselect the interface component that does not apply to your system.

  Note: WinView/32 (versions 2.6.0 and higher) does not support the ISA interface.

Cooling Troubleshooting

Temperature Lock Cannot be Achieved or Maintained.

Caution

Operating a PI-SCX:1300 camera with coolant at a temperature colder than specified could cause induced condensation in the electronics enclosure and possible catastrophic damage to the camera. ***Damage resulting from this type of operation may void the warranty.***

Possible causes could include:

- Ambient temperature greater than +23°C. If it is greater than +23°C, you will need to cool the camera environment or raise the set temperature.
- The vacuum has deteriorated and needs to be refreshed.
- The connectors of the cable that interconnects the controller and the camera need to be secured.
- The target array temperature is not appropriate for your particular camera and CCD array.
- For cameras that are liquid-cooled or have liquid-assisted cooling, the coolant flow rate may be insufficient due to a pinched coolant line, blockages, circulator power problem, or pump failure. Check the flow rate and coolant temperature.
- For a TE-cooled camera, the camera's internal temperature may be too high, such as might occur if the operating environment is particularly warm or if you are attempting to operate at a temperature colder than the specified limit. TE-cooled cameras are equipped with a thermal-protection switch that shuts the cooler circuits down if the internal temperature exceeds a preset limit. Typically, camera operation is restored automatically in about ten minutes. Although the thermo-protection switch will protect the camera, you are nevertheless advised to power down and correct the operating conditions that caused the thermal-overload to occur.

Camera loses Temperature Lock

The internal temperature of the camera is too high. This might occur if the operating environment is particularly warm or if you are trying to operate at a temperature colder than the specified limit. If this happens, an internal thermal overload switch will disable the cooler circuits to protect them. Typically, camera operation is restored in about ten minutes. Although the thermal overload switch will protect the camera, users are advised to power down and correct the operating conditions that caused the thermal overload to occur. *With some versions of the software, the **indicated** temperature when the camera is in thermal overload (thermal switch is in the cut-out state) is -120° C.*

Gradual Deterioration of Cooling Capability

With time, there may be a gradual deterioration of the camera's vacuum. This can affect temperature performance such that it may be impossible to achieve temperature lock at the lowest temperatures. In the kind of applications for which cooled CCD cameras are so well suited, it is highly desirable to maintain the system's lowest temperature performance because lower temperatures result in lower thermal noise and better the signal-to-noise ratio.

Vacuum deterioration occurs primarily as a result of material outgassing in the vacuum chamber. Because outgassing normally diminishes with time, the rate of vacuum

deterioration in new cameras may be faster than in old ones. For example, a camera that has to be repumped after perhaps a year of operation, may not have to be pumped again for several years. In any case you may notice a gradual deterioration in temperature control performance indicative of vacuum deterioration. If this happens, the camera will have to be repumped. Appendix C provides directions for repumping the vacuum. If you have the appropriate equipment and personnel with the necessary expertise available, you may wish to pump down the camera at your facility by following the procedure outlined in Appendix C. If the necessary equipment and expertise isn't available, simply contact the factory to make arrangements for returning the camera to the support facility nearest to you to have the vacuum restored.

Data Loss or Serial Violation

You may experience either or both of these conditions if the host computer has been set up with Power Saving features enabled. This is particularly true for power saving with regard to the hard drive. Make sure that Power Saving features are disabled while you are running WinView/32.

Data Overrun Due to Hardware Conflict message

Figure 34. Data Overrun Due to Hardware Conflict dialog

If this dialog appears when you try to acquire a test image, acquire data, or run in focus mode, check the CCD array size and then check the DMA buffer size. A large array (for example, a 2048x2048 array), requires a larger DMA buffer larger setting than that for a smaller array (for example, a 512x512 array).

To change the DMA buffer setting:

1. Note the array size (on the **Setup|Hardware|Controller/CCD** tab or the **Acquisition|Experiment Setup|Main** tab Full Chip dimensions).
2. Open **Setup|Environment|Environment** dialog.
3. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close the WinX application.
4. Reboot your computer.
5. Restart the WinX application and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Data Overrun Has Occurred message

Because of memory constraints and the way that USB transfers data, a "Data overrun has occurred" message may be displayed during data acquisition. If this message is displayed, take one or more of the following actions:

1. Minimize the number of programs running in the background while you are acquiring data with WinView/32.
2. Run data acquisition in Safe Mode.
3. Add memory.
4. Use binning.
5. Increase the exposure time.
6. Defragment the hard disk.
7. Update the Orange Micro USB2 driver. See ***"To Update the OrangeUSB USB 2.0 Driver:"***, page 33.

If the problem persists, your application may be USB 2.0 bus limited. Since the host computer controls the USB 2.0 bus, there may be situations where the host computer interrupts the USB 2.0 port. In most cases, the interrupt will go unnoticed by the user. However, there are some instances when the data overrun cannot be overcome because USB 2.0 bus limitations combined with long data acquisition times and/or large data sets increase the possibility of an interrupt while data is being acquired. If your experiment requirements include long data acquisition times and/or large data sets, your application may not be suitable for the USB 2.0 interface. Therefore, we recommend replacement of the USB 2.0 interface module with our TAXI interface module and Princeton Instruments (RSPI) PCI card. If this is not the case and data overruns continue to occur, contact Customer Support (see page 108 for contact information).

Demo is only Choice on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)

If RSConfig.exe has not been run and there is not an installed Princeton Instruments (RSPI) high speed PCI card, the Hardware Wizard will only present the choice "Demo" in the Interface dialog (Figure 35). Clicking on **Next** presents an "Error Creating Controller. Error=129." message, clicking on **OK** presents "The Wizard Can Not Continue Without a Valid Selection!" message, clicking on **OK** presents the Interface dialog again.

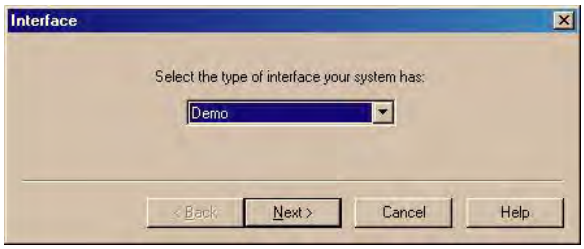


Figure 35. Hardware Wizard: Interface dialog

At this point, you will need to exit WinView and run the RSConfig.exe program, which creates a file called PVCAM.INI. This file contains information required to identify the

interface/camera and is referenced by the Hardware Wizard when you are setting up WinView with USB for the first time:

1. If you have not already done so, close WinView/32.
2. Make sure the ST-133 is connected to the host computer and that it is turned on.
3. Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed WinView.
4. When the RSConfig dialog (Figure 36) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera1". When you have finished, click on the **Done** button.

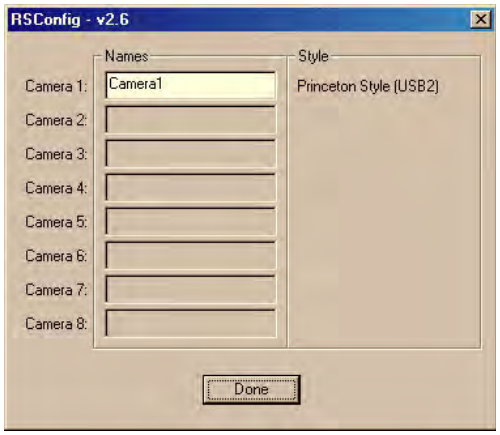


Figure 36. RSConfig dialog

5. You should now be able to open WinView and, from **Setup|Hardware…,** run the Hardware Wizard.
6. When the PVCAM dialog (Figure 37) is displayed, click in the **Yes** radio button, click on **Next** and continue through the Wizard. After the Wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to set up experiments and acquire data.

Figure 37. Hardware Wizard: PVCAM dialog

Demo, High Speed PCI, and PCI(Timer) are Choices on Hardware Wizard:Interface dialog (Versions 2.5.19.0 and earlier)

If there is an installed Princeton Instruments (RSPI) high speed card in the host computer and you want to operate a camera using the USB 2.0 interface, the PVCAM.INI file (created by RSConfig.exe) must exist and the USB 2.0 supported camera must be [Camera_1]. PVCAM.INI, which contains information required to identify the interface/camera, is referenced by the Hardware Wizard when you are setting up WinView/32 with USB for the first time. If the Wizard did not find a PVCAM.INI file or if RSConfig.exe was run but the USB 2.0 camera is [Camera_2] in the PVCAM.INI file, "Demo", "High Speed PCI", and "PCI(Timer)" will be selectable from the Wizard's Interface dialog.

Figure 38. Hardware Wizard: Interface dialog

At this point, you will need to run the RSConfig.exe program:

1. If you have not already done so, close WinView/32.
2. Make sure the ST-133 is connected to the host computer and that it is turned on.
3. Run RSConfig from the **Windows|Start|Programs|PI Acton** menu or from the directory where you installed WinView.
4. When the RSConfig dialog (Figure 39) appears, you can change the camera name to one that is more specific or you can keep the default name "Camera2". When you have finished, click on the **Done** button. You will next edit the generated PVCAM.INI file.

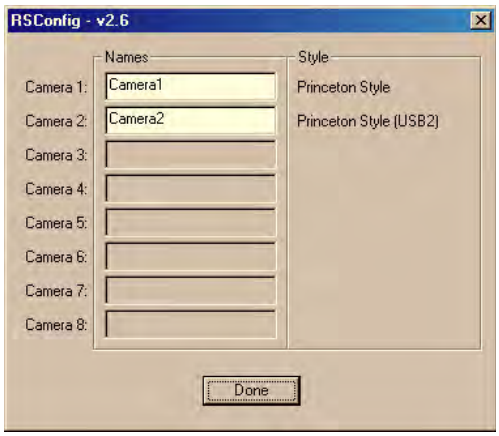


Figure 39. RSConfig dialog: Two Camera Styles

5. Using **Notepad** or a similar text editor, open PVCAM.INI, which is located in the Windows directory (C:\Windows, for example).

If the contents of the file look like: Change the headings so the contents now look like:

[Camera_1]	→	[Camera_2]
Type=1		Type=1
Name=Camera1		Name=Camera1
Driver=rspipci.sys		Driver=rspipci.sys
Port=0		Port=0
[Camera_2]	→	[Camera_1]
Type=1		Type=1
Name=Camera2		Name=Camera2
Driver=apausb.sys		Driver=apausb.sys
Port=0		Port=0

Note: The [Camera_#] must be changed so the camera supported by the USB interface will be recognized (the USB driver is "apausb.sys"). For consistency, you may also want to change the camera names.

6. Save the file. With the ST-133 connected and on, open WinView/32.
7. Run the Hardware Wizard.
8. When the PVCAM dialog (Figure 40) is displayed, click in the **Yes** radio button, click on **Next** and continue through the Wizard. After the Wizard is finished, the **Controller/Camera** tab card will be displayed with the **Use PVCAM** checkbox selected. You should now be able to acquire data.

Figure 40. Hardware Wizard: PVCAM dialog

Detector Temperature, Acquire, and Focus are Grayed Out (Versions 2.5.19.0 and earlier)

These functions and others will be deactivated if you have installed a camera being run under USB 2.0 and have opened WinView/32 without having first turned on the ST-133. They will also be deactivated if you have installed a camera being run under USB 2.0 and a Princeton Instruments high speed PCI card was also detected when RSConfig.exe was run.

1. Check to see if the ST-133 is connected to the host computer and is turned on. If it is not connected or is connected but not turned on, go to Step 2. If it is connected and on, go to Step 3.
2. Close WinView, verify that the ST-133 is connected to the host computer, turn on the ST-133, and reopen WinView. The formerly grayed out functions should now be available.
3. If the ST-133 is connected and on, the USB 2.0 camera may not be listed as Camera 1 in the PVCAM.INI file.
4. Run RSConfig.exe (accessible from the **Windows|Start|Programs|PI Acton** menu). If the USB 2.0 camera is listed as Camera 2 (Princeton Style (USB2) in Figure 41), you will have to edit the PVCAM.INI file.

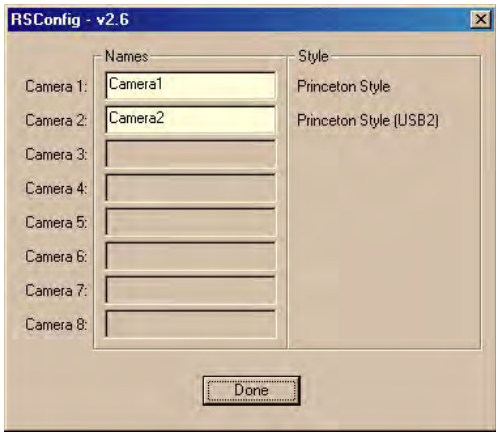


Figure 41. RSConfig dialog: Two Camera Styles

5. Using **Notepad** or a similar text editor, open PVCAM.INI, which is located in the Windows directory (C:\Windows, for example).

If the contents of the file look like: Change the headings so the contents now look like:

[Camera_1] → [Camera_2]
Type=1 Type=1
Name=Camera1 Name=Camera1
Driver=rspipci.sys Driver=rspipci.sys
Port=0 Port=0

[Camera_2] → [Camera_1]
Type=1 Type=1
Name=Camera2 Name=Camera2
Driver=apausb.sys Driver=apausb.sys
Port=0 Port=0

Note: The [Camera_#] must be changed so the camera supported by the USB interface will be recognized (the USB driver is "apausb.sys"). For consistency, you may also want to change the camera names.

6. Save the file. With the ST-133 connected and on, open WinView/32. The formerly grayed out functions should now be available.

Error Creating Controller message

This message may be displayed if you are using the USB 2.0 interface and have not run the RSConfig.exe program (see previous topic), if the PVCAM.INI file has been corrupted, or if the ST-133 was not turned on before you started WinView/32 and began running the Hardware Wizard.

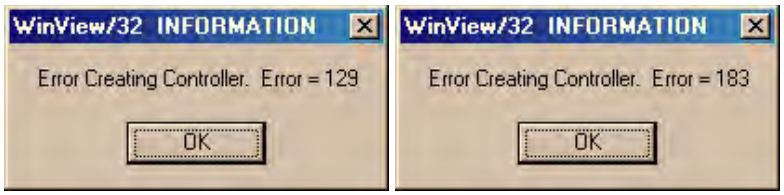


Figure 42. Error Creating Controller dialog

Error 129: Indicates that the problem is with the PVCAM.INI file. Close WinView/32, run RSConfig, make sure the ST-133 is on, reopen WinView, and begin running the Hardware Wizard.

Error 183: Indicates that the ST-133 is off. If you are running the Hardware Wizard when this message appears, click on **OK**, turn on the ST-133, and, on the PVCAM dialog, make sure **Yes** is selected and then click on **Next**. The Hardware Wizard should continue to the Controller Type dialog.

Error Occurs at Computer Powerup

If an error occurs at boot up, either the interface card is not installed properly or there is an address or interrupt conflict. Turn off the computer, reinstall the interface card (make sure it is firmly seated), and reboot the system.

If an error occurs while you are using the WinView/32 program, check the interface selection on the **Hardware Setup|Interface** tab (WinView/32). If the current choice is "High Speed PCI", change the selection to "PCI(Timer)". If the problem goes away, you can either correct the interrupt conflict or you can continue using PCI(Timer) for data transfer (data transfer is controlled by a polling timer rather than interrupts). Note that data transfer can be slower in PCI(Timer) mode on slower computers.

Conflicts

One of the many advantages that PCI offers over ISA is that the whole issue of address and interrupt assignments is user transparent and under BIOS control. As a result, users typically do not have to be concerned about jumpers or switches when installing a PCI card. Nothing more should be required than to plug in the card, make the connections, and operate the system. As it turns out, however, in certain situations conflicts may nevertheless occur and user intervention will be required to resolve them.

Typical PCI motherboards have both ISA and PCI slots and will have both PCI and ISA cards installed. In the case of the ISA cards, the I/O address and Interrupt assignments will have been made by the user and the BIOS will not know which addresses and

interrupts have been user assigned. When a PCI card is installed, the BIOS checks for available addresses and interrupt levels and automatically assigns them so that there are no *PCI* address or interrupt conflicts. However, because the BIOS doesn't know about the user-assigned ISA I/O address and interrupt level assignments, it is possible that a PCI card will be assigned an address or interrupt that is already assigned to an ISA card. If this happens, improper operation will result. Specifically, the problems could range from erratic operation under specific conditions to complete system failure. If such a conflict occurs, because the user has no control over the PCI address and interrupt assignments, there will be no recourse but to examine the .ISA assignments and change them to values which do not conflict. Most (but by no means all) ISA cards make provision for selecting alternative I/O addresses and interrupt levels so that conflicts can be resolved. Software is available to help identify specific conflicts.

The following example may serve to illustrate the problem. Suppose you had a system with an ISA network card, a PCI video card and an ISA sound card. Further suppose that you were then going to install a PCI Serial Buffer card. Before installing the PCI Serial card, the I/O address and interrupt assignments for the installed cards might be as follows.

Slot Type	Status	I/O Address	Interrupt
1 (ISA)	ISA Network Card	200-210	11
2 (PCI)	PCI Video Card	FF00-FFFF	15
3 (ISA)	ISA Sound Card	300-304	9
4 (PCI)	Empty	N/A	N/A

Table 6. I/O Address & Interrupt Assignments before Installing Serial Card

As shown, there are no conflicts, allowing the three peripheral cards to operate properly. If the PCI Serial card were then installed, the BIOS would interrogate the PCI cards and may reassign them new address and interrupt values as follows.

Slot Type	Status	I/O Address(s)	Interrupt
1 (ISA)	ISA Network Card	200-210	11
2 (PCI)	PCI Video Card	FE00-FEFF	11
3 (ISA)	ISA Sound Card	300-304	9
4 (PCI)	Princeton Instruments PCI Serial Card	FF80-FFFF	15

Table 7. I/O Address & Interrupt Assignments after Installing Serial Card

As indicated, there is now an interrupt conflict between the ISA Network Card and the PCI Video card (both cards have been assigned Interrupt 11), causing the computer to no longer function normally. This doesn't mean that the PCI Serial card is defective because the computer stops functioning properly when the Serial card is installed. What it does mean is that there is an interrupt conflict that can be resolved by changing the interrupt level on the conflicting Network card in this example. It is up to the user to consult the documentation for any ISA cards to determine how to make the necessary change.

Note: Changing the order of the PCI cards, that is, plugging them into different slots, could change the address and interrupt assignments and possibly resolve the conflict. However, this would be a trial and error process with no guarantee of success.

Diagnostics Software

Many diagnostics programs, both shareware and commercial, are available to help resolve conflicts. Most often, all that's required is a program that will read and report the address and interrupt assignments for each PCI device in the computer. One such program available from Princeton Instruments' Customer Support department is called PCICHECK. When the program is run, it reports the address and interrupt assignments for the first PCI device it finds. Each time the spacebar is pressed, it moves on to the next one and reports the address and interrupt assignments for that one as well. In a few moments this information can be obtained for every PCI device in the computer. Note that, even though there are generally only three PCI slots, the number of PCI devices reported may be larger because some PCI devices may be built onto the motherboard. A good strategy for using the program would be to run it before installing the PCI Serial card. Then run it again after installing the card and note any address or interrupt assignments that may have changed. This will allow you to easily focus on the ones that may be in conflict with address or interrupt assignments on ISA cards. It might be noted that there are many programs, such as the MSD program supplied by Microsoft, that are designed to read and report address and interrupt assignments, including those on ISA cards. Many users have had mixed results at best using these programs.

Operation

There are no operating considerations that are unique to the PCI Serial card. The card can easily accept data as fast as any Princeton Instruments System now available can send it. The incoming data is temporarily stored in the card’s memory, and then transferred to the main computer memory when the card gains access to the bus. The PCI bus arbitration scheme assures that, as long as every PCI card conforms to the PCI guidelines, the on-board memory will never overflow.

Unfortunately, there are some PCI peripheral cards that do ***not*** fully conform to the PCI guidelines and that take control of the bus for longer periods than the PCI specification allows. Certain video cards (particularly those that use the S3 video chip) are notorious in this respect. Usually you will be able to recognize when memory overflow occurs because the displayed video will assume a split-screen appearance and/or the message **Hardware Conflict** will be displayed (WinView/32). At the same time, the LED on the upper edge of the PCI Serial card will light.

Users are thus advised not to take any actions that would worsen the possibility of memory overflow occurring when taking data. In that regard, avoid multitasking while taking data. Specific operations to avoid include multitasking (pressing ALT TAB or ALT ESC to start another program), or running a screensaver program.

No CCD Named in the Hardware Wizard:CCD dialog (Versions 2.5.19.0 and earlier)

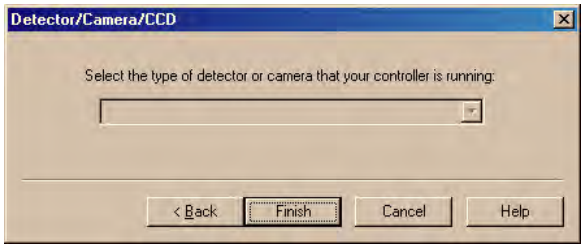


Figure 43. Hardware Wizard: Detector/Camera/CCD dialog

If you have installed a USB 2.0 Interface Module in your ST-133, a blank field may be displayed in the Detector/Camera/CCD dialog (Figure 43) if the ST-133 controller was made before January 2001. Earlier versions of the ST-133 did not contain non-volatile RAM (NVRAM), which is programmed with information about the controller and the camera. PVCAM, the program under which the Princeton Instruments USB works, retrieves the information stored in NVRAM so it can enter specific camera characteristics into WinView/32.

Check the serial label on underside of your controller. If the first five characters are D1200 (December 2000) or earlier (J0797 or July 1997, for example), contact Customer Support to find out about an NVRAM controller upgrade.

Program Error message

Program Error
Winview.exe has generated errors and will be closed by Windows.
You will need to restart the program.
An error log is being created.
OK

Figure 44. Program Error dialog

This dialog may appear if you have tried to acquire a test image, acquire data, or run in focusing mode and the DMA buffer size is too small. A large array (for example, a 2048x2048 array), requires a larger setting than that for a smaller array (for example, a 512x512 array).

To correct the problem:

1. Click on **OK**.
2. Reboot the WinX application.
3. Note the array size (on the **Setup|Hardware|Controller/CCD** tab or the **Acquisition|Experiment Setup|Main** tab Full Chip dimensions). If your camera contains a large array (such as a 2048x2048 array), and the DMA buffer size is too small, there will not be enough space in memory for the data set.
4. Open **Setup|Environment|Environment** dialog.
5. Increase the DMA buffer size to a minimum of 32 Mb (64 Mb if it is currently 32 Mb or 128 Mb if it is currently 64 Mb), click on **OK**, and close the WinX application.

6. Reboot your computer.
7. Restart the WinX application and begin acquiring data or focusing. If you see the message again, increase the DMA buffer size.

Removing/Installing a Plug-In Module

The ST-133 Controller has three plug-in slots. The Analog/Control module (leftmost slot when the controller is viewed from the rear) and the Interface Control module (either a TAXI or a USB 2.0 compatible module in the middle slot) are always provided. The third slot, however, is covered with a blank panel unless a PTG module has been installed in the ST-133.

If a module is ever removed for any reason, internal settings should ***not*** be disturbed. Changing a setting could radically alter the controller's performance. Restoring normal operation again without proper equipment and guidance would be very difficult, and it might be necessary to return the unit to the factory for recalibration.

Note: If you have an installed PTG and are changing from one interface type to another (TAXI to USB 2.0 or USB 2.0 to TAXI), contact Customer Support for specific changeover instructions. See page 108 for contact information.

WARNINGS!

1. Always turn the Controller OFF before removing or installing a module. If a module is removed or installed when the controller is powered, permanent equipment damage could occur which would not be covered by the warranty.
2. Before handling any boards, take precautions to prevent electrostatic discharge (ESD). The modules are susceptible to ESD damage. Damage caused by improper handling is not covered by the Warranty.

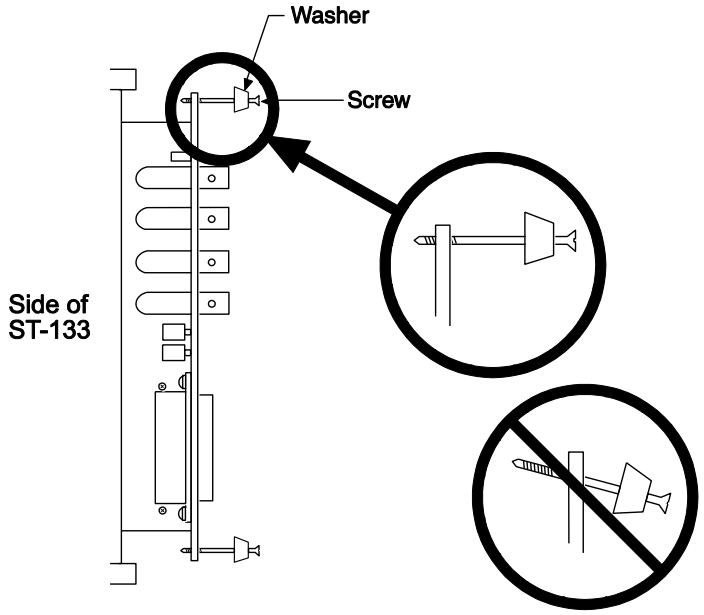


Figure 45. Module Installation

To Remove a Module:

1. Verify that the Controller has been turned OFF.
2. Rotate the two locking screws (one at the top of the module and one at the bottom) counterclockwise until they release from the chassis.
3. Then, grasp the module and pull it straight out.
4. Set the module aside in a safe place. If you are replacing it with another module, as in the case of exchanging a TAXI module for a USB 2.0 module, you may be able to use the packaging from the new module to store the old module. This packaging is usually an antistatic bag that will protect the module components from electrostatic discharge.

To Install a Module:

Installing a module is a bit more complex because you first have to be sure the locking screws are aligned correctly. The following procedure is suggested.

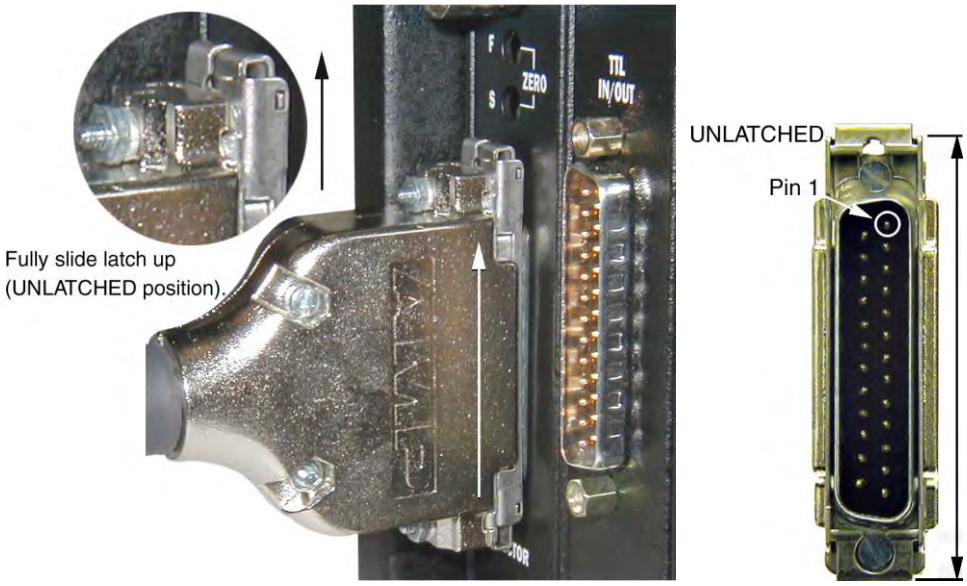
1. Verify that the Controller has been turned OFF.
2. Remove the replacement module from its antistatic packaging. This packaging is designed to protect the module components from electrostatic discharge.
3. Rotate the two locking screws counterclockwise until the threads on the screws engage those of the module panel. *See Figure 45.* By doing this, the screws will be perfectly perpendicular to the module panel and will align perfectly when the module is inserted.
4. Insert the module so the top and bottom edges of the board are riding in the proper guides.
5. Gently but firmly push the module in until the 64-pin DIN connector at the back of the module mates with the corresponding connector on the backplane, leaving the module panel resting against the controller back panel.
6. Rotate the two locking screws clockwise. As the screws are rotated, they will first disengage from the module panel threads, and then begin to engage those of the bracket behind the controller panel.

WARNING! Tighten the screws to where they are just snug. Do ***not*** tighten them any further because you could easily bend the mating bracket.

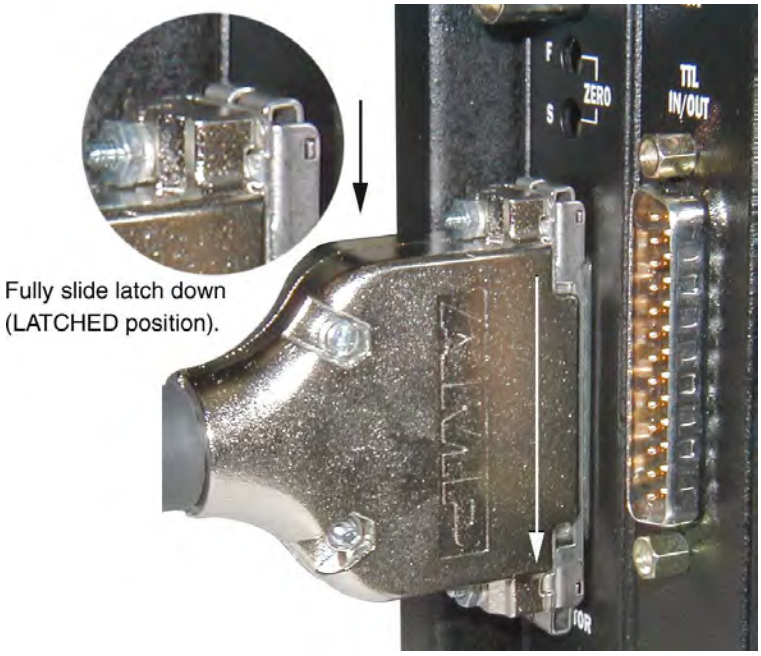
Securing the Detector-Controller Cable Slide Latch

Some Princeton Instruments Detector-Controller cables use a slide latch to secure the Detector-Controller cable to the DETECTOR connector on the back of the ST-133. Incorrectly plugging this cable into the connector and improperly securing the slide latch may prevent communication with the PI-SCX (the camera may appear to stop working).

1. Before trying to plug in the cable, slide the latch up (toward Pin 1). Then, plug the cable into the DETECTOR connector on the ST-133.



2. Slide the latch down. You may hear a click when the latch locks.



3. Verify that the connector is fully secured.

If you are having trouble sliding the latch, slightly pull the connector out and then slide the latch into its locked position.

Serial violations have occurred. Check interface cable.

Figure 46. Serial Violations Have Occurred dialog

This error message dialog will appear if you try to acquire an image or focus the camera and either (or both) of the following conditions exists:

- The camera system is not turned ON.
- There is no communication between the camera and the host computer.

To correct the problem:

1. Turn **OFF** the camera system (if it is not already OFF).
2. Make sure the Detector-Controller cable is secured at both ends and that the computer interface cable is secured at both ends.
3. After making sure that the cables are connected, turn the camera system power **ON**.
4. Click **OK** on the error message dialog and retry acquiring an image or running in focus mode.

Note: This error message will also be displayed if you turn the camera system OFF or a cable comes loose while the application software is running in Focus mode.

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Appendix A
Specifications

CCD Arrays

Types

The following list is not necessarily current. Other chips may also be available. Contact the factory for up-to-date information.

Model	CCD (WinView/32 Name)	Pixel Format	Pixel Size	CCD Type
1300	EEV CCD36-40 (EEV 1300x1340F)	1300 × 1340	20 × 20 µm	100 kHz/1 MHz, Full Frame
4300	Kodak KAF 4300E (KAF 2084x2084 SCX)	2084 × 2084	24 × 24 µm	1 MHz, Full Frame
4096	Fairchild CCD486 (FCD 4096x4096F)	4096 × 4091	15 × 15 µm	1 MHz, Full Frame

PI-SCX:1300

Array Size: 1340x1300

Pixel Size: 20x20 µm

Spectral Range (typical): 400-1100 nm

Cooling: Air or Water

Output Amplifiers: Low-noise (~ 250,000 e^-) and High-capacity (≥500,000 e^-)

Parallel Shift Rate: 30 µs/row

Dual A/D: 100 kHz and 1 MHz

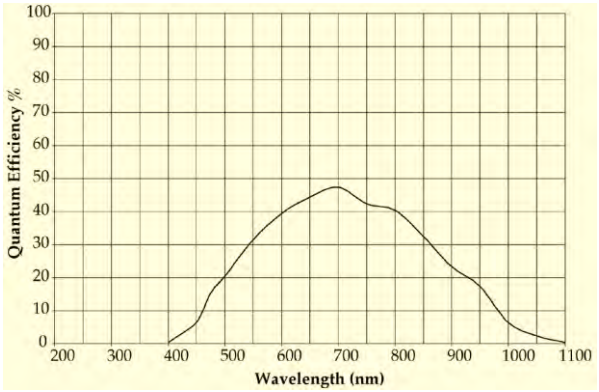
Readout Rates:

Full Frame: ~ 1.8 s @ 1 MHz, ~18.0 s @ 100 kHz

2x2 Binning: ~ 0.65 s @ 1 MHz, ~4.8 s @ 100 kHz

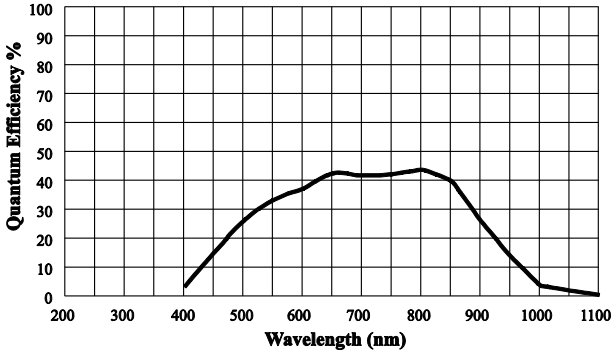
8x8 Binning: ~ 0.15 s @ 1 MHz, ~ 0.5 s @ 100 kHz

Quantum Efficiency:



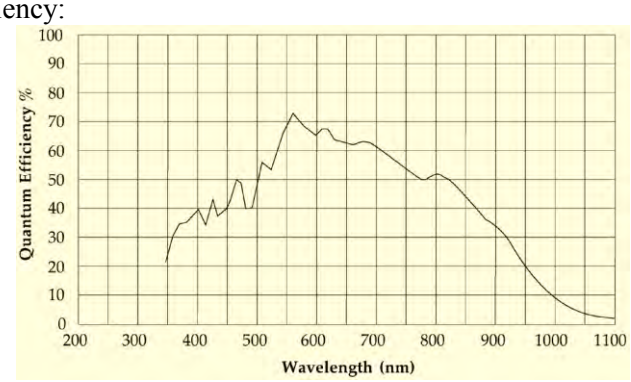
PI-SCX:4096

Array Size: 4096x4096
Pixel Size: 15x15 µm
Spectral Range (typical): 400-1000 nm
Cooling: Water
Output Amplifier: Single port
Parallel Shift Rate: 200 µs/row
Pixel Well: 70 Ke^- min, 85 Ke^- typical
Quantum Efficiency:



PI-SCX:4300

Array Size: 2084x2084
Pixel Size: 24x24 µm
Spectral Range (typical): 350-1000 nm
Cooling: Water
Output Amplifiers: Low-noise and High-capacity
Parallel Shift Rate: 70 µs/row
Quantum Efficiency:



Camera Window

Beryllium (Be); 10 mil (250 µm) thick

Camera Connector

Male, D-subminiature 25-pin power/signal connector

Camera Cooling

PI-SCX:1300: -30°C (forced air) to -35°C (water cooled at +25°C) thermoelectric (Peltier)

PI-SCX:4096: -50°C with +5°C water (≤1.5:1 fiber ratio); -45°C with +0°C water (>1.5:1 fiber ratio)

PI-SCX:4300: -50°C with +5°C water

Passive Cooling: CCD array cooled by Peltier device. Heat is radiated away by cooling fins on body of the round head camera.

Supplemental Air Cooling: The PI-SCX:1300 camera may have an internal fan that draws air in from the vents in the camera shell, circulates it past the internal cooling fins, and then exhausting the warmed air back into the atmosphere.

Water Cooling: Mixture of 50% ethylene glycol and 50% water pumped through coolant ports at the side of the camera (PI-SCX:1300) or the rear of the camera (PI-SCX:4096 and PI-SCX:4300).

Temperature Control

Setting Mechanism: Temperature is set by the application software.

Display: The actual temperature can be displayed at the computer by the application software.

Control Precision: ±0.05°C; closed-loop stabilized-temperature control

Cooldown Temperature (typical): As long as the ambient temperature is between +18°C and +23°C and the humidity is <50%, PI-SCX CCDs can typically be cooled down to the following temperatures:

Camera	Cooldown Temperature
PI-SCX:1300	30°C with forced air
	-35°C with water cooling (water at +25°C)
PI-SCX:4096	-50°C with +5°C circulating water for fiber ratio ≤ 1.5:1
	-45°C with +0°C circulating water for fiber ratio >1.5:1
PI-SCX:4300	-50°C with +5°C circulating water

Table 8. Camera vs. Approximate Cooldown Temperature

If the ambient temperature is greater than +23°C, temperature lock may not be achievable at the above temperatures

Gain

Software selectable (high, medium, low)

Dimensions

All dimensions are approximate and subject to change. Refer also to the outline drawings in Appendix B.

PI-SCX:1300

4.63 in (11.8 cm) width;
4.63 in (11.8 cm) height;
8.71 in (22.15 cm) length;
10 lb (4.54 kg) weight

PI-SCX:4096 ≤ 1.5:1

6.00 in (15.24 cm) width;
6.00 in (15.24 cm) height;
7.94 in (20.17 cm) length;
35 lb (15.89 kg) weight

PI-SCX:4096 >1.5:1

8.50 in (21.59 cm) width;
8.50 in (21.59 cm) height;
9.20 in (23.37 cm) length;

PI-SCX:4300

6.00 in (15.24 cm) width;
6.00 in (15.24 cm) height;
8.41 in (21.36 cm) length;
35 lb (15.89 kg) weight

Controller TTL I/O

Input: External Sync

Output: READY (Not Ready) frame start; SCAN (Not Scan) shutter/readout status

Controller I/O

Male, D-subminiature 25-pin connector; 8 TTL inputs; 8 TTL outputs

Controller Interface

Female, D-subminiature 9-pin connector for RS232 serial communication

Controller Power Input

Refer to the Fuse/Voltage label on the back of the ST-133 for fuse, voltage, and power consumption information.

Controller Dimensions

Dimensions: See Appendix B.
Controller Weight: ST-133A: 13 lb (5.9 kg); ST-133B: 12.5 lb (5.7 kg)

Mounting

PI-SCX:1300 The optional Tripod mount provides one each 1/4"-20, 3/8"-16, and M6 mounting hole.

PI-SCX:4096 and **PI-SCX:4300** There are two M8 × 1.25 tap (25 mm deep) and one 1/4″–20 tap (0.5″ deep).

Appendix B
Outline Drawings

Note: All dimensions are in inches unless otherwise noted.

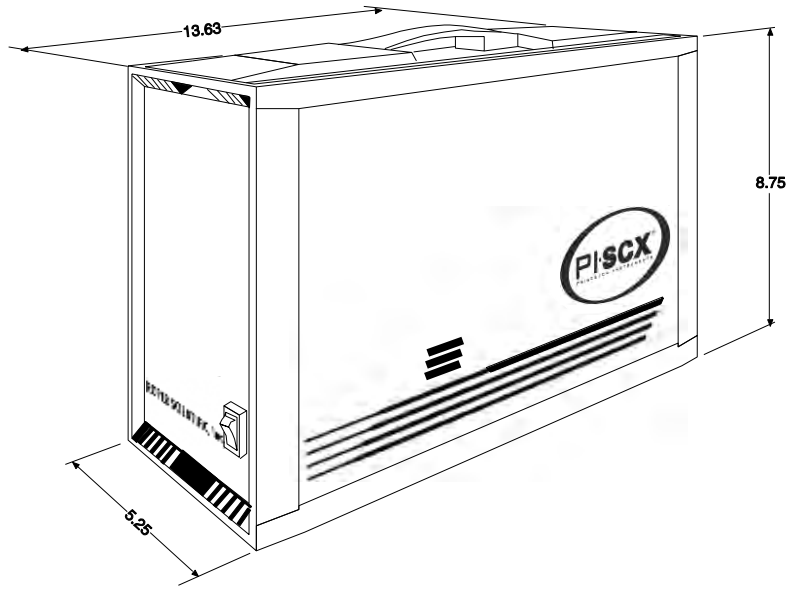


Figure 47. ST-133A Controller

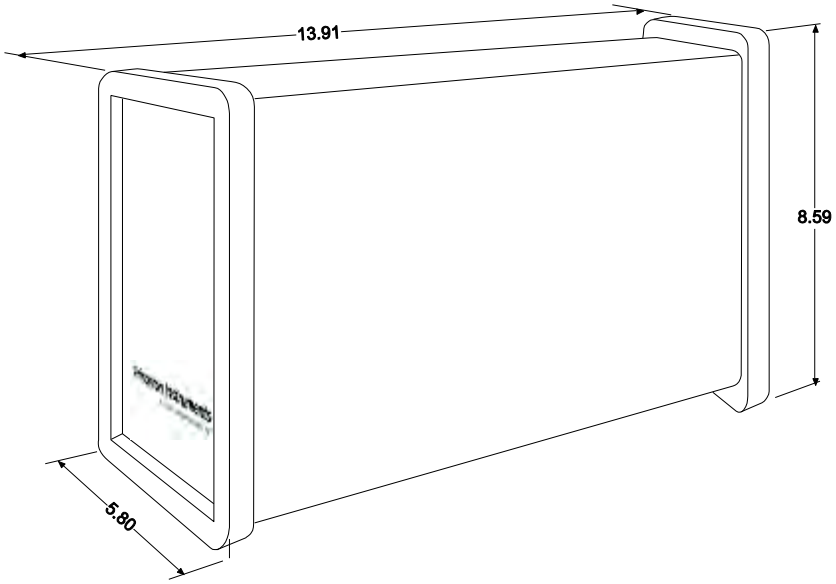


Figure 48. ST-133B Controller

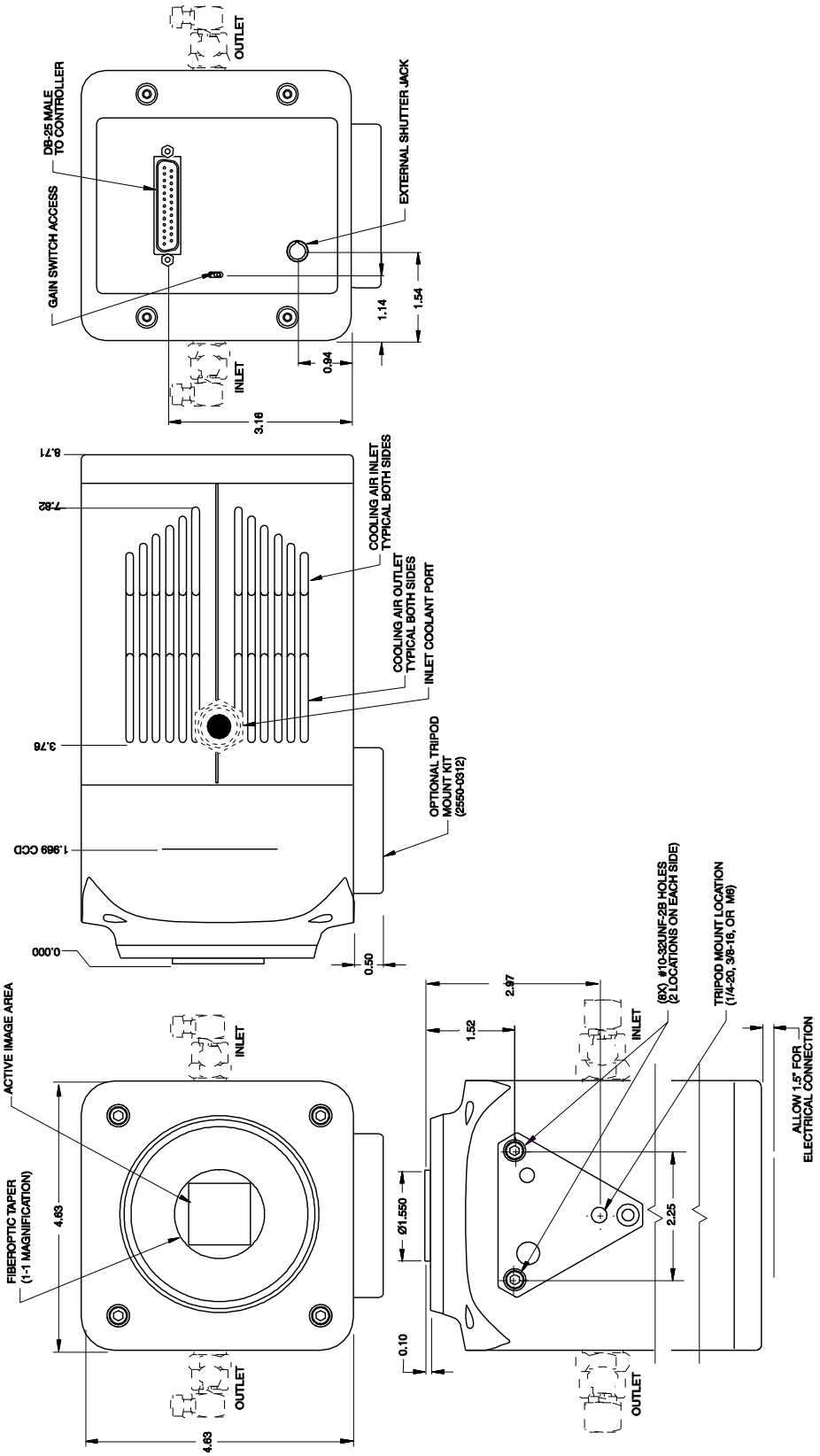


Figure 49. PI-SCX:1300

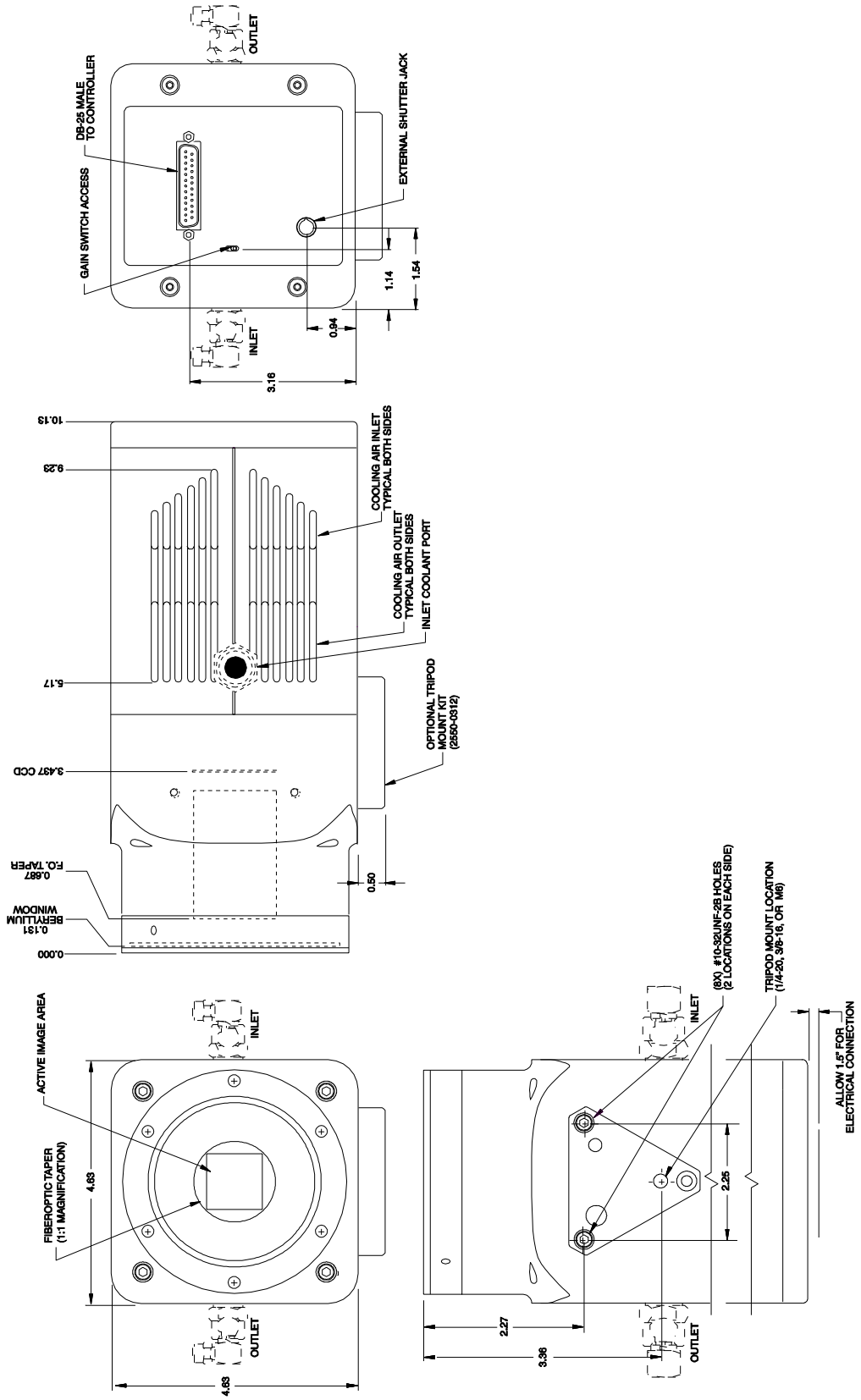


Figure 50. PI-SCX:1300/PW

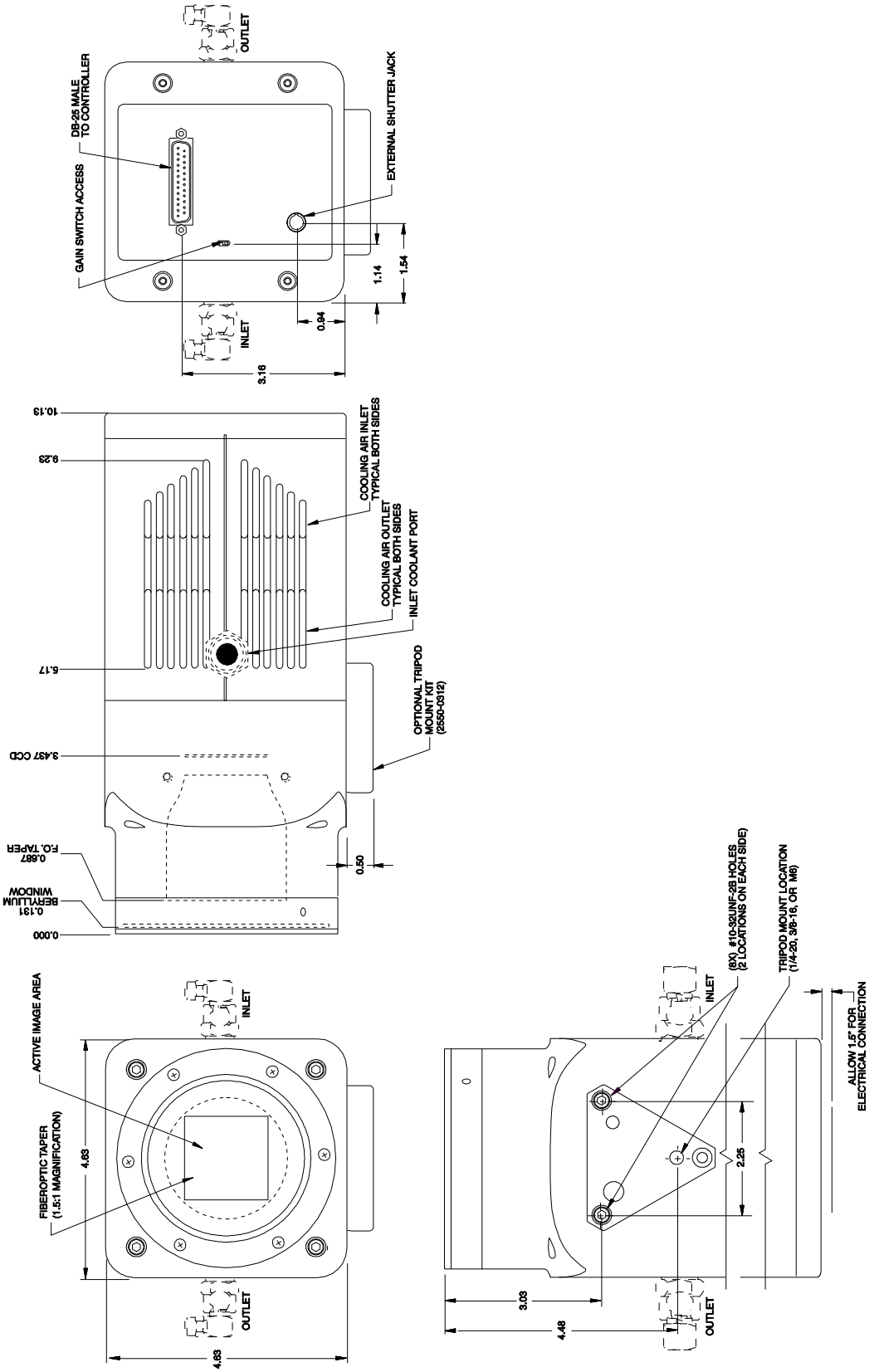


Figure 51. PI-SCX:1300/1.5PW

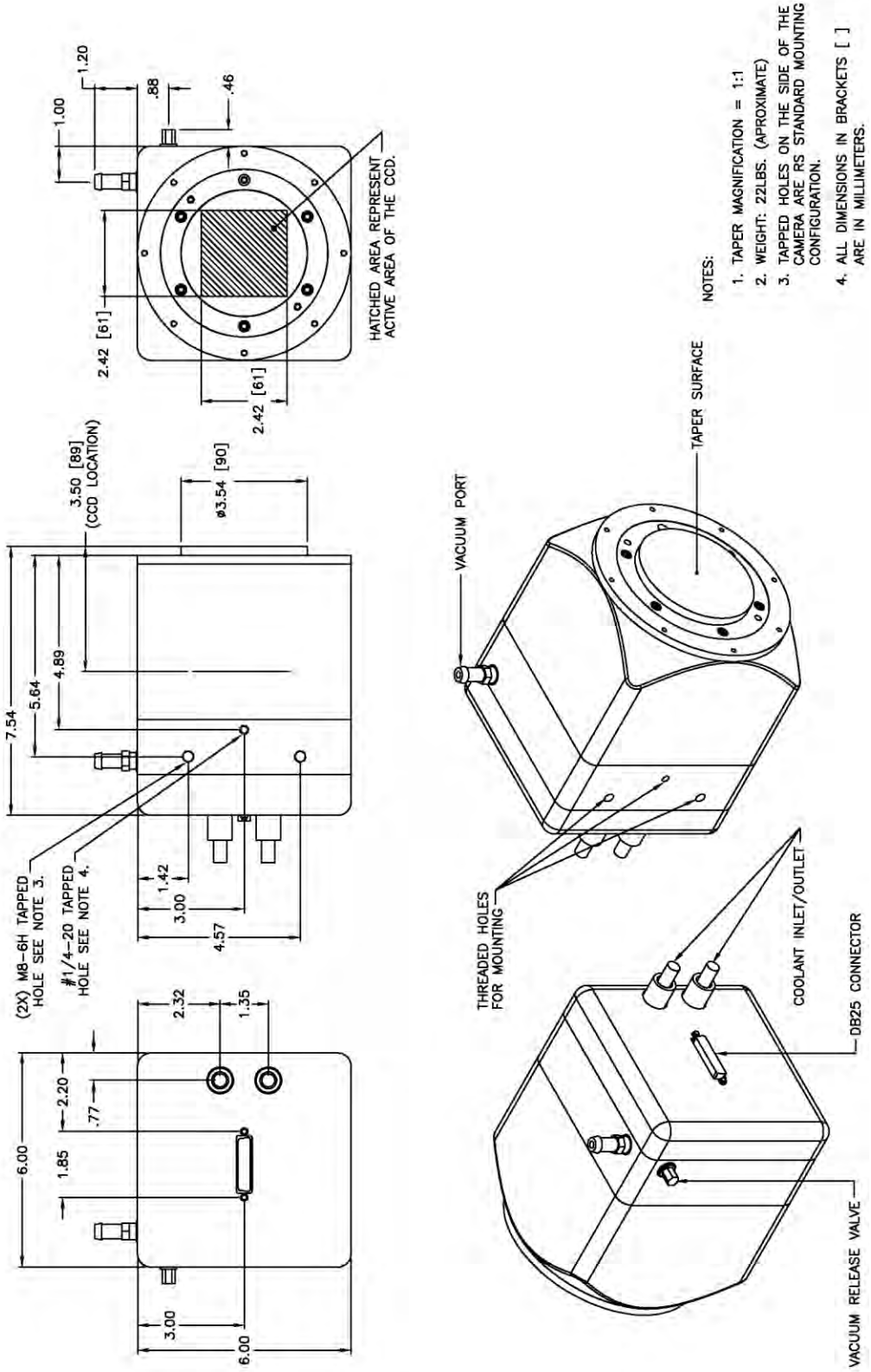


Figure 52. PI-SCX:4096 (100 mm Fiber Optic)

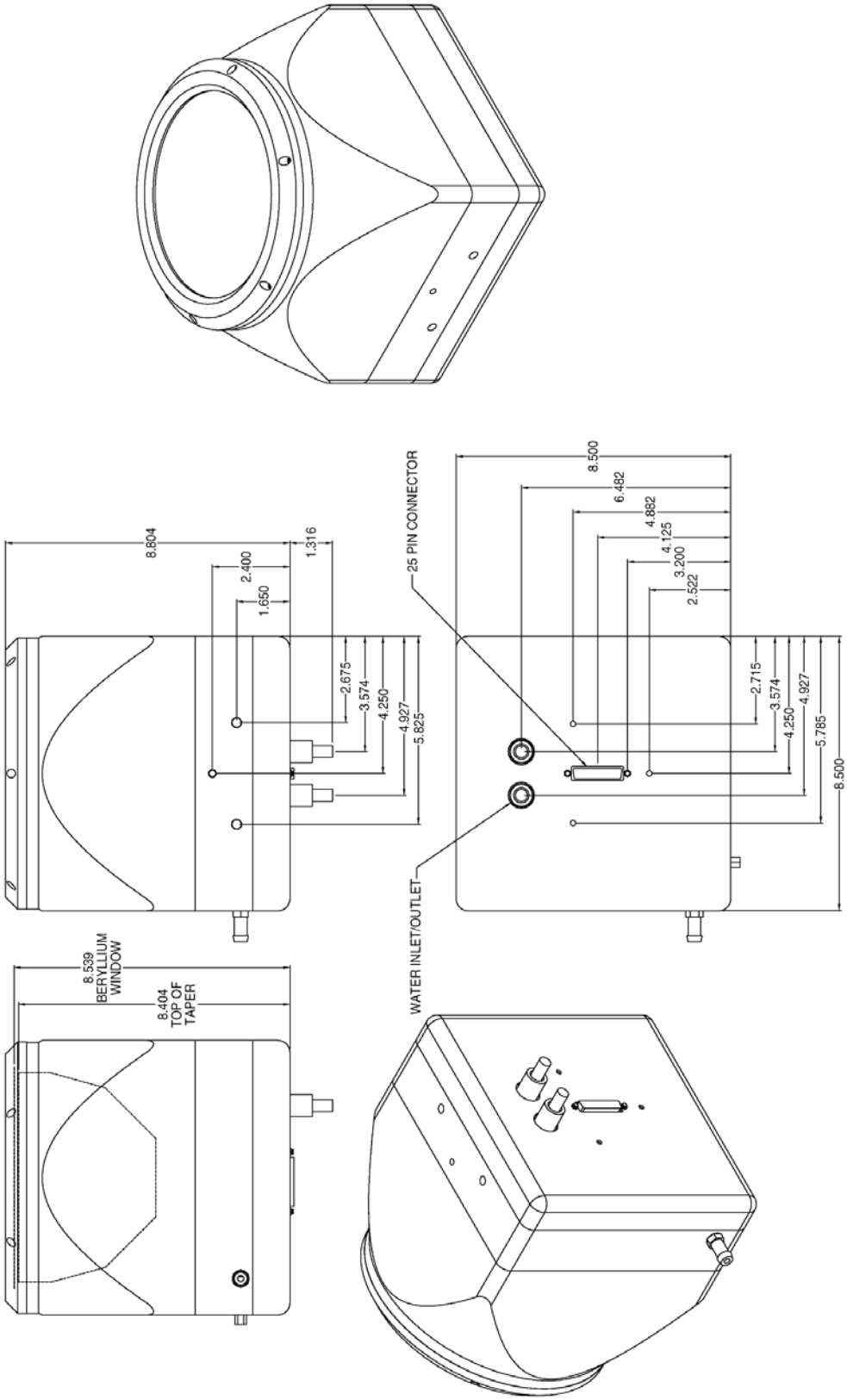


Figure 53. PI-SCX:4096 (165 mm Fiber Optic)

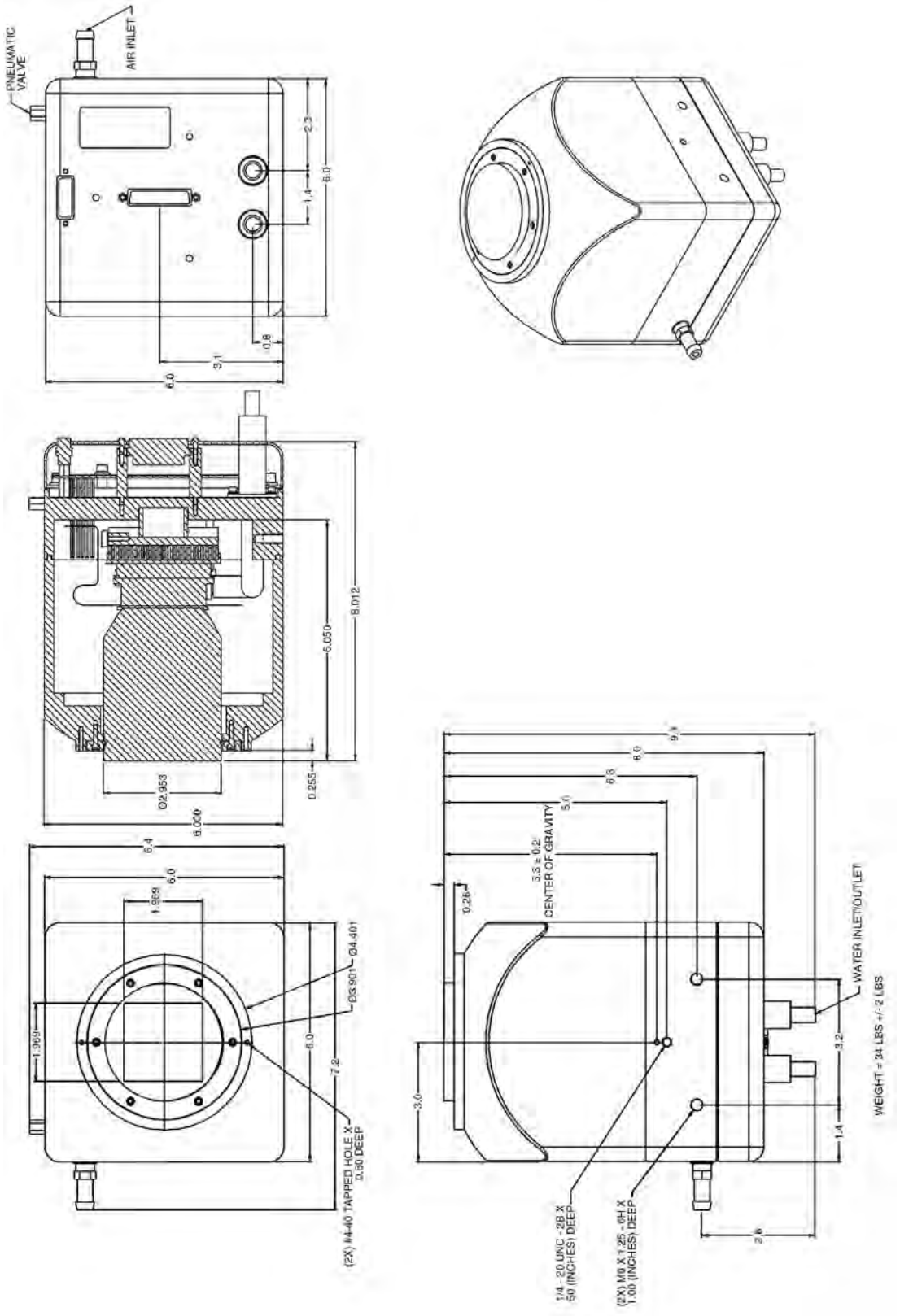


Figure 54. PI-SCX:4300 (75 mm Fiber Optic)

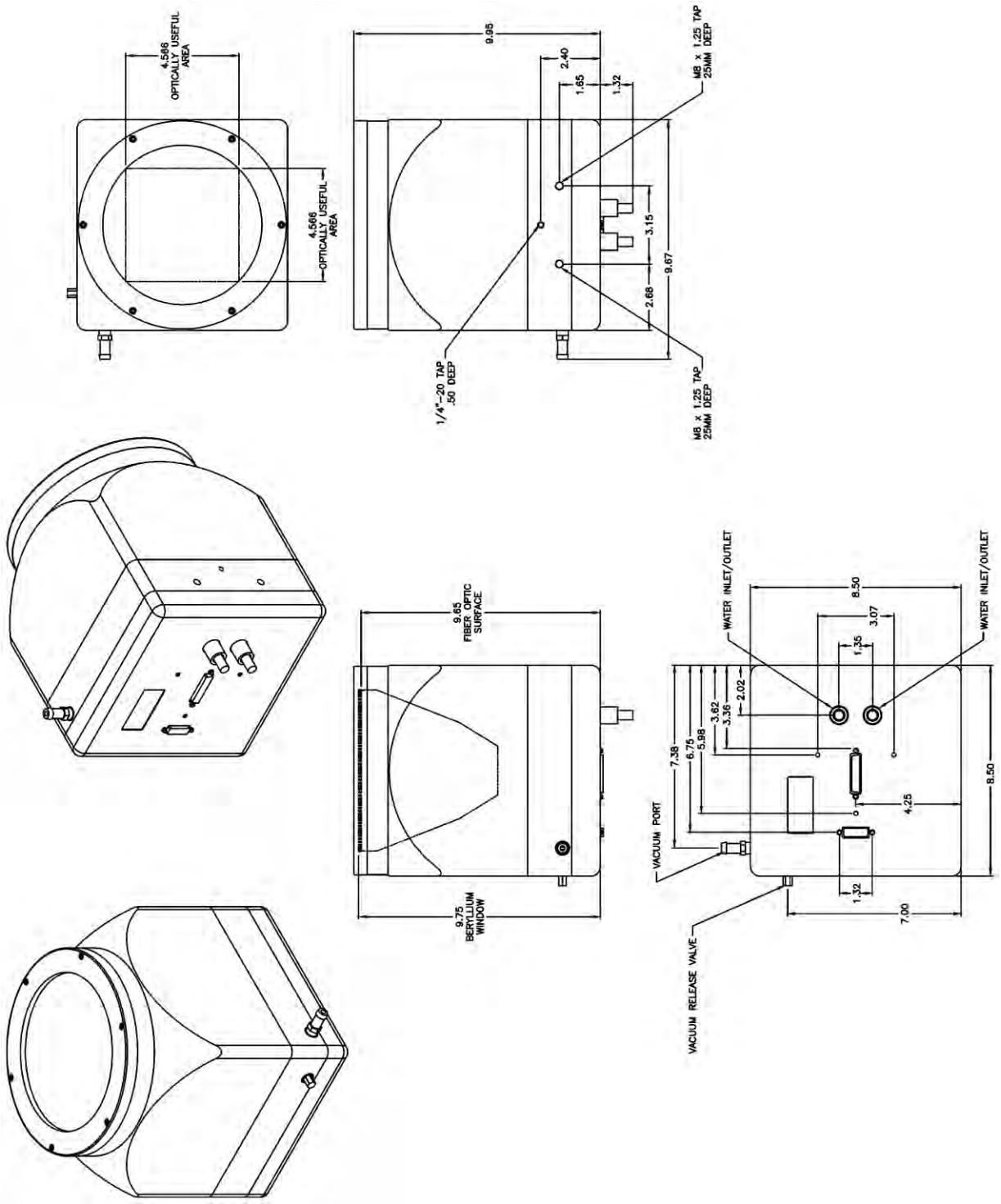


Figure 55. PI-SCX:4300 (165 mm Fiber Optic)

Appendix C
Repumping the Vacuum

Introduction

Fiberoptic taper CCD cameras are shipped with a vacuum level below 10^{-5} Torr to assure proper cooling performance and to prevent condensation from collecting on the CCD. In time, the vacuum level could deteriorate to where achieving temperature lock will no longer be possible. If this happens, it will be necessary to restore the vacuum.

A ¼″ Vacuum Pumping fitting (Figure 56) is supplied with the camera but is not factory installed. The access port, located at the top of the camera, is capped. The cap can easily be removed, allowing the vacuum pumping fitting to be installed.

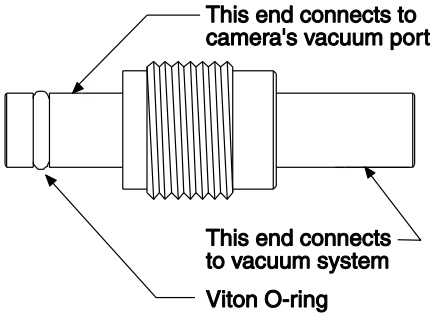


Figure 56. Vacuum Pumping Fitting

A special Indium-tipped Vacuum Seal (Figure 57) is installed in the side of the camera (see Figure 15 on page 39). At installation, the Vacuum Seal's Indium tip is crushed to provide a metal-to-metal seal in the vacuum chamber. The number of times this can be done before a new Vacuum Seal is required is limited. Typically, an Indium tip can be crushed up to ten times before the Vacuum Seal must be replaced to assure a good vacuum seal. Because the tip is crushed only once at the factory, it can be successfully used again numerous times in the field. With repeated repumpings, however, it will eventually be necessary to replace the Indium-tipped Vacuum Seal (PI #2550-0352).

Note: The required seating torque for successful vacuum sealing is 28 in. lb. (3.2 Nm).

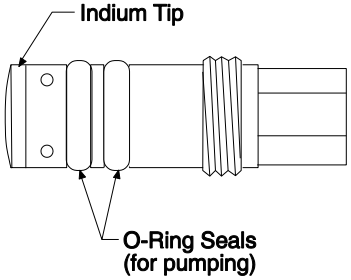


Figure 57. Indium-tipped Vacuum Valve

Requirements

- A laboratory-type vacuum pump capable of achieving absolute pressures below 10 mTorr.

Caution Your vacuum system must have a trap (ideally cryogenic) placed between the camera and the pump to prevent contamination due to oil backstreaming from the pump.

- 5/16″ hex torque wrench for tightening the Indium-tipped Vacuum Seal.
- A new Indium-tipped Vacuum Seal (PI #2550-0352). A new seal will only be required if the camera has been repumped a number of times and the original seal is no longer able to maintain vacuum.

Pumping Procedure

WARNING! Wait at least two hours after the camera was last operated before proceeding. This is necessary so that the CCD can warm to ambient before being opened to the atmosphere. If opened when still cold, potentially harmful condensation could form on the CCD.

Preliminary Steps

1. Turn off the system power and disconnect all cables.
2. Apply a light coating of high-quality vacuum grease such as Apiezon M to the O-ring on the Vacuum Pumping Fitting supplied with the system.
3. Remove the cap from the vacuum access port at the top of the camera.
4. Insert the end of the Vacuum Pumping Fitting into the port at the top of the camera to where the threads can be engaged. Then tighten it down. *Finger tight is sufficient. The greased O-ring makes the seal.*
5. Connect the vacuum hose from the pump to the ¼″ fitting at the end of the Vacuum Pumping fitting and clamp the hose connection securely.
6. ***If you are going to reuse the currently installed Indium-tipped Vacuum Seal***, turn on the vacuum pump. Then:
   - Using the 5/16″ hex torque wrench, rotate the Indium-tipped Vacuum Seal two full revolutions counterclockwise, *just enough* to unseal the vacuum.
   - Perform the steps outlined in the ***"Pumping Down"*** section, located on the following page.
7. ***If you are going to install a new Indium-tipped Vacuum Seal***, do not turn on the pump. Instead, perform the steps outlined in the section titled ***"Installing a New Vacuum Seal"***, which follows the ***"Pumping Down"*** section.

Pumping Down

1. Do not bake during pumping. Maintain ambient temperature (≈25°C).
2. Continue pumping for 48 hr. The final vacuum must be below 10 mTorr. *At the factory, a much higher initial vacuum level is generated using a turbo pump. Although this is desirable, it is not necessary and may be cost prohibitive for the user to purchase similar equipment; 10 mTorr is sufficient to assure normal operation of the unit.*
3. When the required vacuum level has been achieved, tighten down the Indium-tipped Vacuum Seal with the 5/16″ torque wrench to crush the Indium tip and reseal the vacuum. A sealing torque of 28 in. lb. or 3.2 Nm is required.
4. Shut down the pump and remove the vacuum hose from the Vacuum Pumping fitting. Although it shouldn't be required, a 7/16″ nut driver may prove helpful in removing the fitting.
5. Replace the vacuum port cap.

Installing a New Vacuum Seal

Caution

Preventing atmospheric contamination of the vacuum chamber is imperative to the operation and longevity of the camera.

- Placing the camera inside a plastic bag filled with dry nitrogen gas prior to removing the Vacuum Seal will backfill the camera when the Vacuum Seal is removed and help prevent contamination. *Consult the factory.*
- Alternatively, a dry nitrogen pressure may be applied to the vacuum pumping fitting before removing the vacuum valve. Pressure should be 3 psig or less. Maintain a flow of nitrogen until the valve is replaced in Step 3. *Consult the factory.*

1. Using the 5/16" hex torque wrench, rotate the Indium-tipped Vacuum Seal counterclockwise to where the threads completely disengage and then remove it from the vacuum block.
2. Lightly grease the Viton O-ring on the new Indium-tipped Vacuum Seal. Use a high-quality grade of vacuum grease such as Apiezon M.
3. Carefully insert the new Indium-tipped Vacuum Seal into the corresponding opening on the camera vacuum block to where the threads can be engaged – a turn or two is sufficient. ***Do not rotate the plunger to where it bottoms out. The Indium tip should not be disturbed until the new vacuum has been established.***
4. Turn on the pump and follow the ***"Pumping Down"*** instructions.

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Appendix D
USB 2.0 Limitations

The following information covers the currently known limitations associated with operating under the USB 2.0 interface.

- Maximum cable length is 5 meters (16.4 feet)
- 1 MHz is currently the upper digitization rate limit for the ST-133 Controller.
- Large data sets and/or long acquisition times may be subject to data overrun because of host computer interrupts during data acquisition.
- USB 2.0 is not supported by the Princeton Instruments PC Interface Library (EasyDLLs).
- Some WinX (WinView and WinSpec) 2.5.X features are not fully supported with USB 2.0. See the table below.

Feature	Supported with USB 2.0 in WinX 2.5.X	Remarks
Demo Port Capability	NO	
DIF	NO	
Kinetics	YES	WinX 2.5.18.1
Reset Camera to NVRAM Defaults	NO	
Temperature Lock Status	YES	WinX 2.5.x doesn't utilize hardware lock status
PTG	YES	
Virtual Chip	NO	
Custom Timing	YES	WinX 2.5.18.1
Custom Chip	YES	WinX 2.5.18.1
Frames per Interrupt	NO	
RS170 (Video Output)	NO	
Online Exposure	NO	
File Information	YES	Not all header info is currently available in WinX 2.5.x through PVCAM
Overlapping ROIs	NO	
Macro Record	YES	Macros recorded for non-PVCAM cameras may have to be re-recorded to function
TTL I/O	NO	

Table 9. WinView/WinSpec Features Supported under USB 2.0

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Declaration of Conformity

We,

ROPER SCIENTIFIC

(PRINCETON INSTRUMENTS)

3660 QUAKERBRIDGE ROAD

TRENTON, NJ 08619

Declare under our sole responsibility, that the product

ST-133 CONTROLLER
w/SCX CAMERA HEAD,

To which this declaration relates, is in conformity with general safety requirement for electrical equipment standards:

IEC 1010-1:1990, EN 61010-1:1993/A2:1995

EN 61326 for Class A, 1998,

(EN 61000-4-2, EN 61000-4-3, EN 61000-4-4, EN 61000-4-5,

EN 61000-4-6, EN 61000-4-11)

Which follow the provisions of the

CE LOW VOLTAGE DIRECTIVE 73/23/EEC

And

EMC DIRECTIVE 89/336/EEC.

Date: August 15, 2002
TRENTON, NJ

(PAUL HEAVENER)
Engineering Manager

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Warranty & Service

Limited Warranty

Princeton Instruments, a division of Roper Scientific, Inc. ("Princeton Instruments", "us", "we", "our") makes the following limited warranties. These limited warranties extend to the original purchaser ("You", "you") only and no other purchaser or transferee. We have complete control over all warranties and may alter or terminate any or all warranties at any time we deem necessary.

Basic Limited One (1) Year Warranty

Princeton Instruments warrants this product against substantial defects in materials and / or workmanship for a period of up to one (1) year after shipment. During this period, Princeton Instruments will repair the product or, at its sole option, repair or replace any defective part without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, to a factory-authorized service center. You are responsible for the shipping costs to return the product. International customers should contact their local Princeton Instruments authorized representative/distributor for repair information and assistance, or visit our technical support page at www.princetoninstruments.com.

Limited One (1) Year Warranty on Refurbished or Discontinued Products

Princeton Instruments warrants, with the exception of the CCD imaging device (which carries NO WARRANTIES EXPRESS OR IMPLIED), this product against defects in materials or workmanship for a period of up to one (1) year after shipment. During this period, Princeton Instruments will repair or replace, at its sole option, any defective parts, without charge to you. You must deliver the entire product to the Princeton Instruments factory or, at our option, a factory-authorized service center. You are responsible for the shipping costs to return the product to Princeton Instruments. International customers should contact their local Princeton Instruments representative/distributor for repair information and assistance or visit our technical support page at www.princetoninstruments.com.

XP Vacuum Chamber Limited Lifetime Warranty

Princeton Instruments warrants that the cooling performance of the system will meet our specifications over the lifetime of an XP style detector (has all metal seals) or Princeton Instruments will, at its sole option, repair or replace any vacuum chamber components necessary to restore the cooling performance back to the original specifications at no cost to the original purchaser. *Any failure to "cool to spec" beyond our Basic (1) year limited warranty from date of shipment, due to a non-vacuum-related component failure (e.g., any components that are electrical/electronic) is NOT covered and carries NO WARRANTIES EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Sealed Chamber Integrity Limited 12 Month Warranty

Princeton Instruments warrants the sealed chamber integrity of all our products for a period of twelve (12) months after shipment. If, at anytime within twelve (12) months from the date of delivery, the detector should experience a sealed chamber failure, all parts and labor needed to restore the chamber seal will be covered by us. *Open chamber products carry NO WARRANTY TO THE CCD IMAGING DEVICE, EXPRESSED OR IMPLIED.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Vacuum Integrity Limited 12 Month Warranty

Princeton Instruments warrants the vacuum integrity of "Non-XP" style detectors (do not have all metal seals) for a period of up to twelve (12) months from the date of shipment. We warrant that the detector head will maintain the factory-set operating temperature without the requirement for customer pumping. Should the detector experience a Vacuum Integrity failure at anytime within twelve (12) months from the date of delivery all parts and labor needed to restore the vacuum integrity will be covered by us. Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Image Intensifier Detector Limited One Year Warranty

All image intensifier products are inherently susceptible to Phosphor and/or Photocathode burn (physical damage) when exposed to high intensity light. Princeton Instruments warrants, with the exception of image intensifier products that are found to have Phosphor and/or Photocathode burn damage (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all image intensifier products for a period of one (1) year after shipment. *See additional Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

X-Ray Detector Limited One Year Warranty

Princeton Instruments warrants, with the exception of CCD imaging device and fiber optic assembly damage due to X-rays (which carry NO WARRANTIES EXPRESSED OR IMPLIED), all X-ray products for one (1) year after shipment. S*ee additional Basic Limited One (1) year Warranty terms and conditions above, which apply to this warranty.* Responsibility for shipping charges is as described above under our Basic Limited One (1) Year Warranty.

Software Limited Warranty

Princeton Instruments warrants all of our manufactured software discs to be free from substantial defects in materials and / or workmanship under normal use for a period of one (1) year from shipment. Princeton Instruments does not warrant that the function of the software will meet your requirements or that operation will be uninterrupted or error free. You assume responsibility for selecting the software to achieve your intended results and for the use and results obtained from the software. In addition, during the one (1) year limited warranty. The original purchaser is entitled to receive free version upgrades. Version upgrades supplied free of charge will be in the form of a download from the Internet. Those customers who do not have access to the Internet may obtain the version upgrades on a CD-ROM from our factory for an incidental shipping and handling charge. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Owner's Manual and Troubleshooting

You should read the owner's manual thoroughly before operating this product. In the unlikely event that you should encounter difficulty operating this product, the owner's manual should be consulted before contacting the Princeton Instruments technical support staff or authorized service representative for assistance. If you have consulted the owner's manual and the problem still persists, please contact the Princeton Instruments technical support staff or our authorized service representative. *See Item 12 in the following section of this warranty ("Your Responsibility") for more information.*

Your Responsibility

The above Limited Warranties are subject to the following terms and conditions:

1. You must retain your bill of sale (invoice) and present it upon request for service and repairs or provide other proof of purchase satisfactory to Princeton Instruments.
2. You must notify the Princeton Instruments factory service center within (30) days after you have taken delivery of a product or part that you believe to be defective. With the exception of customers who claim a "technical issue" with the operation of the product or part, all invoices must be paid in full in accordance with the terms of sale. Failure to pay invoices when due may result in the interruption and/or cancellation of your one (1) year limited warranty and/or any other warranty, expressed or implied.
3. All warranty service must be made by the Princeton Instruments factory or, at our option, an authorized service center.
4. Before products or parts can be returned for service you must contact the Princeton Instruments factory and receive a return authorization number (RMA). Products or parts returned for service without a return authorization evidenced by an RMA will be sent back freight collect.
5. These warranties are effective only if purchased from the Princeton Instruments factory or one of our authorized manufacturer's representatives or distributors.
6. Unless specified in the original purchase agreement, Princeton Instruments is not responsible for installation, setup, or disassembly at the customer's location.
7. Warranties extend only to defects in materials or workmanship as limited above and do not extend to any product or part which has:
   - been lost or discarded by you;
   - been damaged as a result of misuse, improper installation, faulty or inadequate maintenance or failure to follow instructions furnished by us;
   - had serial numbers removed, altered, defaced, or rendered illegible;
   - been subjected to improper or unauthorized repair; or
   - been damaged due to fire, flood, radiation, or other "acts of God" or other contingencies beyond the control of Princeton Instruments.
8. After the warranty period has expired, you may contact the Princeton Instruments factory or a Princeton Instruments-authorized representative for repair information and/or extended warranty plans.
9. Physically damaged units or units that have been modified are not acceptable for repair in or out of warranty and will be returned as received.
10. All warranties implied by state law or non-U.S. laws, including the implied warranties of merchantability and fitness for a particular purpose, are expressly limited to the duration of the limited warranties set forth above. With the exception of any warranties implied by state law or non-U.S. laws, as hereby limited, the

forgoing warranty is exclusive and in lieu of all other warranties, guarantees, agreements, and similar obligations of manufacturer or seller with respect to the repair or replacement of any parts. In no event shall Princeton Instruments' liability exceed the cost of the repair or replacement of the defective product or part.

11. This limited warranty gives you specific legal rights and you may also have other rights that may vary from state to state and from country to country. Some states and countries do not allow limitations on how long an implied warranty lasts, when an action may be brought, or the exclusion or limitation of incidental or consequential damages, so the above provisions may not apply to you.
12. When contacting us for technical support or service assistance, please refer to the Princeton Instruments factory of purchase, contact your authorized Princeton Instruments representative or reseller, or visit our technical support page at www.princetoninstruments.com.

Contact Information

Roper Scientific's manufacturing facility for this product is located at the following address:

Princeton Instruments
3660 Quakerbridge Road
Trenton, NJ 08619 (USA)

Tel: 800-874-9789 / 609-587-9797
Fax: 609-587-1970

Customer Support E-mail: techsupport@princetoninstruments.com

For immediate support in your area, please call the following locations directly:

America	1.877.4.PIACTON (877.474.2286)
Benelux	+31 (347) 324989
France	+33 (1) 60.86.03.65
Germany	+49 (0) 89.660.7793
Japan	+81 (3) 5639.2741
UK & Ireland	+44 (0) 28.3831.0171

Otherwise, see our Support web page at www.princetoninstruments.com. An up-to-date list of addresses and telephone numbers is posted on the www.princetoninstruments.com/Support page. In addition, links on this page to support topics allow you to send e-mail based requests to the Customer Support group.

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